AD 689106

PROJECT REPORT
Project No.
68-460-3

Evaluation of MDC/EAL STOL Demonstration

May 1969

FEDERAL AVIATION ADMINISTRATION

Department of Transportation
FEDERAL AVIATION ADMINISTRATION
Flight Standards Service
Washington, D. C.

113

T E C H N I C A L

R E P O R T

Evaluation of the
M D C / E A L
Northeast Corridor
STOL Demonstration

Project No.
68-460-3

Prepared by:

Barney 'B' Bryant

Frank Parr

May 1969

Department of Transportation
FEDERAL AVIATION ADMINISTRATION
Flight Standards Service
National Flight Inspection Division
Oklahoma City, Oklahoma

C FAA AC 69-7483

ABSTRACT

Data were collected during a joint Eastern Airlines/McDonnell Douglas demonstration of the Breguet STOL transport aircraft in the New York City area. Analysis of data was directed to the terminal area maneuvering requirements. Turning radii for 80 knots IAS with a 15 degree bank angle appeared correct for use as a minimum standard in the development of departure routes and holding patterns. The angle between successive route segments limits the minimum distance between the waypoints used to establish the intercepted segment.

CONTENTS

LIST OF FIGURES

A Technical Report on data gathered during a joint Eastern Airlines and McDonnell Douglas Corporation demonstration of the McDonnell Douglas (MDC) 188 (Breguet 941) STOL aircraft.

Project Officer	Barney B Bryant Barney B Bryant Flight Procedures Evaluation Section
Concur	E. E. Callaway E. E. Callaway Chief, Standards Development Branch
Approved	Earl E Blanchard E. E. Blanchard Chief, National Flight Inspection Division
Released	for James F. Rudolph Director, Flight Standards Service

INTRODUCTION

The cumulative effect of jet transport growth has been near saturation of several major terminals with both air and ground traffic. Industry and government have been exploring new vehicles, navigation and guidance systems, and air traffic control procedures for relief of this congestion. The STOL aircraft has been proposed to expedite traffic flow in these terminal areas.

A joint program by the McDonnell Douglas Aircraft Corporation and Eastern Airlines was established to evaluate the feasibility of using this type aircraft in the Northeast corridor operation. The Breguet 941, designated the McDonnell Douglas Corporation (MDC) 188, was used in a demonstration of the practicability of interterminal STOL operations conducted independently of conventional traffic. The aircraft was equipped for computerized guidance and with VORTAC, DECCA, and LORAN-C navigational capability.

Personnel from the Flight Standards Service participated in the program to provide data acquisition, reduction, and analysis services. The project presented the opportunity to examine closely a STOL operation superimposed on existing conventional aircraft operations at a major high density airport and terminal area.

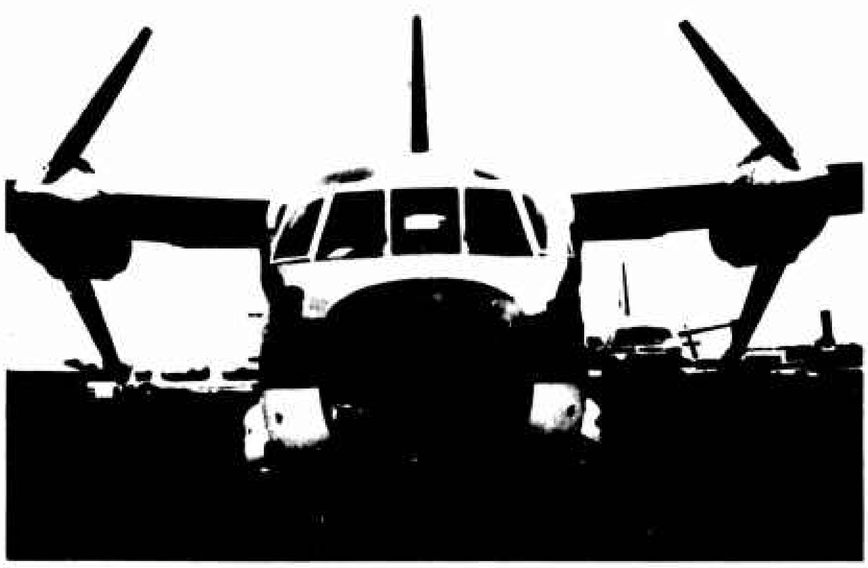


FIGURE 1. McDonnell Douglas Corporation (MDC) 188 STOL Aircraft (Breguet 941).

STATEMENT OF THE PROBLEM

Terminal area airspace assignments and flight procedures are now predicated upon conventional fixed wing aircraft capabilities. STOL operations as proposed for the major air traffic areas will require substantial review to allow a combined operation. Data are needed to identify the flight procedures and airspace requirements appropriate to STOL performance capabilities.

OBJECTIVE

The objective of this project effort is to:

> Evaluate the terminal area maneuvering requirements for the STOL aircraft from the enroute environment to the final approach fix (FAF).

TEST METHODS

Aircraft position data were derived from three sources:

1. Aircraft tracks were recorded on DECCA Omnitrac equipment aboard the MDC-188. The flights were either local flights entirely within the New York metropolitan area or inter-terminal flights via area navigation (R-NAV) routes in the Boston, New York, and Washington air traffic complex. Data for this report were collected over R-Nav routes in the New York terminal area, within approximately 30 miles of the LaGuardia (LGA) radar antenna site.

2. Aircraft positioning records were obtained from the Airborne Instrument Laboratories (AIL) beacon digitizer located in the Kennedy International Airport common IFR room.

3. Aircraft position data were also recorded by a radar photographic method using the ASR-4 radar scope in the LGA IFR room.

DATA ACQUISITION

1. <u>Airborne Data Record</u>. A member of the Flight Standards project team was aboard the demonstration aircraft during all data collection flights. The flight crew member assigned to operate the navigational equipment labeled the Omnitrac records with the type of navigation system in use and with date/time information for correlation with other data records. For control of data collection and accuracy of data reduction, the preferred procedure was to require a fresh Omnitrac chart for each pattern or radial flown. Since project personnel were the guests of Eastern Airlines, our requirements were secondary to the primary mission of evaluation, and this was not always possible. As a result, quality control of the airborne data was less than optimum. Electronic equipment problems, trouble shooting, and airborne computer adjustments and calibrations resulted in the major emphasis being on equipment maintenance rather than on the routine and statistically valid data acquisition techniques normally appropriate for an operational evaluation of this type.

2. <u>AIL Beacon Digitizer Record</u>. In conjunction with the UNIVAC 1219 computer and printer, the beacon digitizer provided a direct readout of the aircraft position. Two beacon transponders located on the ground provided "permanent echoes" for reference, and a transponder mounted in the aircraft provided aircraft position information. The data produced by the beacon digitizer consist of bearing and distance from the radar antenna. The digitizer was flight checked at an altitude suitable for STOL terminal operations. This flight check provided position space points based on signals from four DME stations simultaneously within their service range along the route established for the STOL operation. Position information established by the digitizer was compared mathematically with the flight check space points using regression analysis. The results of this comparison indicate that the variation of the digitizer information was the same as the variation of the space point system.

3. <u>Radar Camera Record</u>. A video map of the special STOL terminal route was prepared and flight checked by Eastern Region personnel. The ASR-4 radar scope with the special video map was located in the LGA IFR room. This scope was fitted with a data camera connected to the radar console. During operations, the STOL aircraft was identified after takeoff, and a cursor was used to identify its radar reflection throughout the flight within the 30 NM range of the radar. The data camera automatically recorded the scope display and an attached data chamber at each sweep of the radar antenna. For correlation of the photo data with the Omnitrac record and beacon digitizer, and for sequence identification, the data chamber contained a clock and frame counter. Photographic records were made on 35mm film. Any time the demonstration aircraft was within 40 NM of the LGA ASR antenna the data camera was being attended by a project team member.

DATA REDUCTION

Decca Omnitrac charts used for data acquisition are shown in Appendix 2. These charts are drawn in a scale of 1 inch to 2/3 miles. They are identified by date, time period (AM or PM), and run number. For example, the first two charts shown are identified as "10/1/68AM Run 1" and "10/1/68AM Run 2".

Beacon difitizer data were plotted on the Omnitrac charts. See sample chart, Figure 2, Page 5. Digitizer positions are seen as circles around position location dots. The intended flight track is shown by the heavy line. Data plots were begun with the first recorded position of the aircraft and at approximately 30 second intervals until the signal was lost. There were times when the radar did not receive the beacon signal at the desired time, so these points were projected to the nearest time. These radar "misses" may have been due to the shielding of the transponder antenna in a turn, a code change, or other causes.

Measurements were taken between the digitizer plotted position and the nearest points on the proposed flight tracks. These distances were then tabulated for analysis. A cumulative graph of these measurements can be seen in Figure 3. The Omnitrac charts used in these measurements are shown in Appendix 2, Figures 9 through 97.

Data acquired by radar photographic techniques will be retained as reference material as may be required.

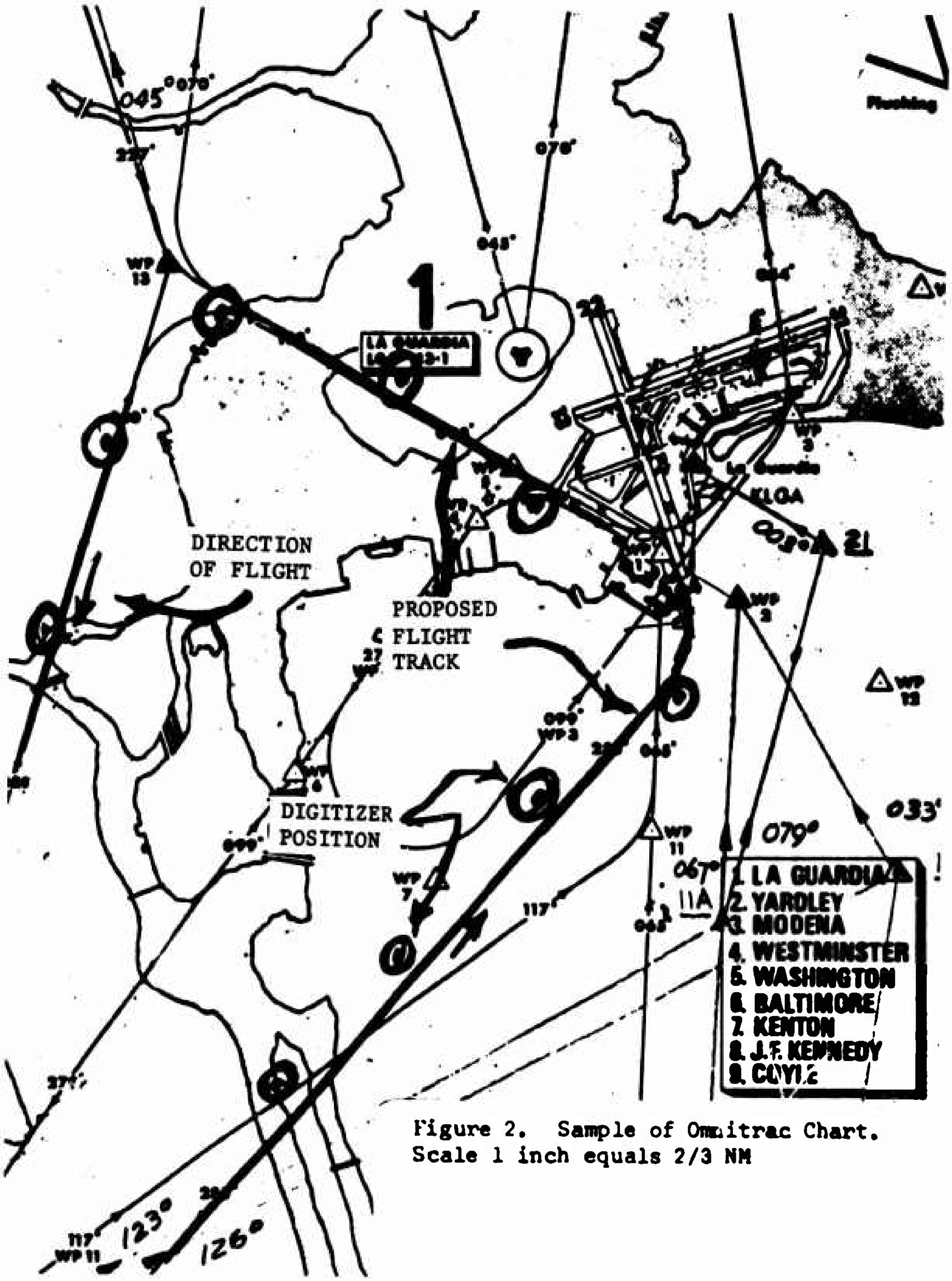


Figure 2. Sample of Omnitrac Chart. Scale 1 inch equals 2/3 NM

DATA ANALYSIS

Data analysis was directed toward the overall terminal area maneuvering requirements. Areas considered for evaluation were determined to be satisfactory or unsatisfactory based upon the capability of the aircraft to maintain the proposed route or track.

Measurements taken from the Omnitrac charts shown in Appendix 2 show that 95.6 percent of the digitizer sample points were within .4 NM of the proposed tracks. Samples recorded during 360 degree turns were not used in this compilation. A graph (Figure 3) shows the cumulative distribution of digitizer sample points in distance from proposed track by percentage.

Under one set of circumstances the departure route to Boston requires a takeoff to the northwest and a circling track to the LEFT to a northeast heading. Of the 5 separate departures where this route was used, 3 tracks were inside the proposed pattern and 2 were outside. This dispersion appears to support the use of a .4 NM turn radius, which is approximately that for 80 knots IAS and a 15 degree bank, using the formula:

$$\text{Radius}(R) = \frac{V^2}{g \tan \theta}$$

Where g = 32.17, θ = bank angle, and V = TAS(Knots) x 1.689. The resultant R will be indicated in feet.

Charts showing the 5 departures are found in Figures 51, 53, 59, 63, and 64, in Appendix 2.

Most of the way-points and routes appear to be satisfactory. One area of concern developed on some of the early runs, however (Appendix 2, Figures 11 and 15).
When the route required a sharp turn (over 60 degrees) followed by a relatively short distance to the next way-point (7000 feet), the flight director disregarded and by-passed the next way-point, and established an intercept for the FOLLOWING leg. When the distance was increased to allow the intercept of the desired course within the limitations of the airborne computer, the by-passes appeared to be eliminated.

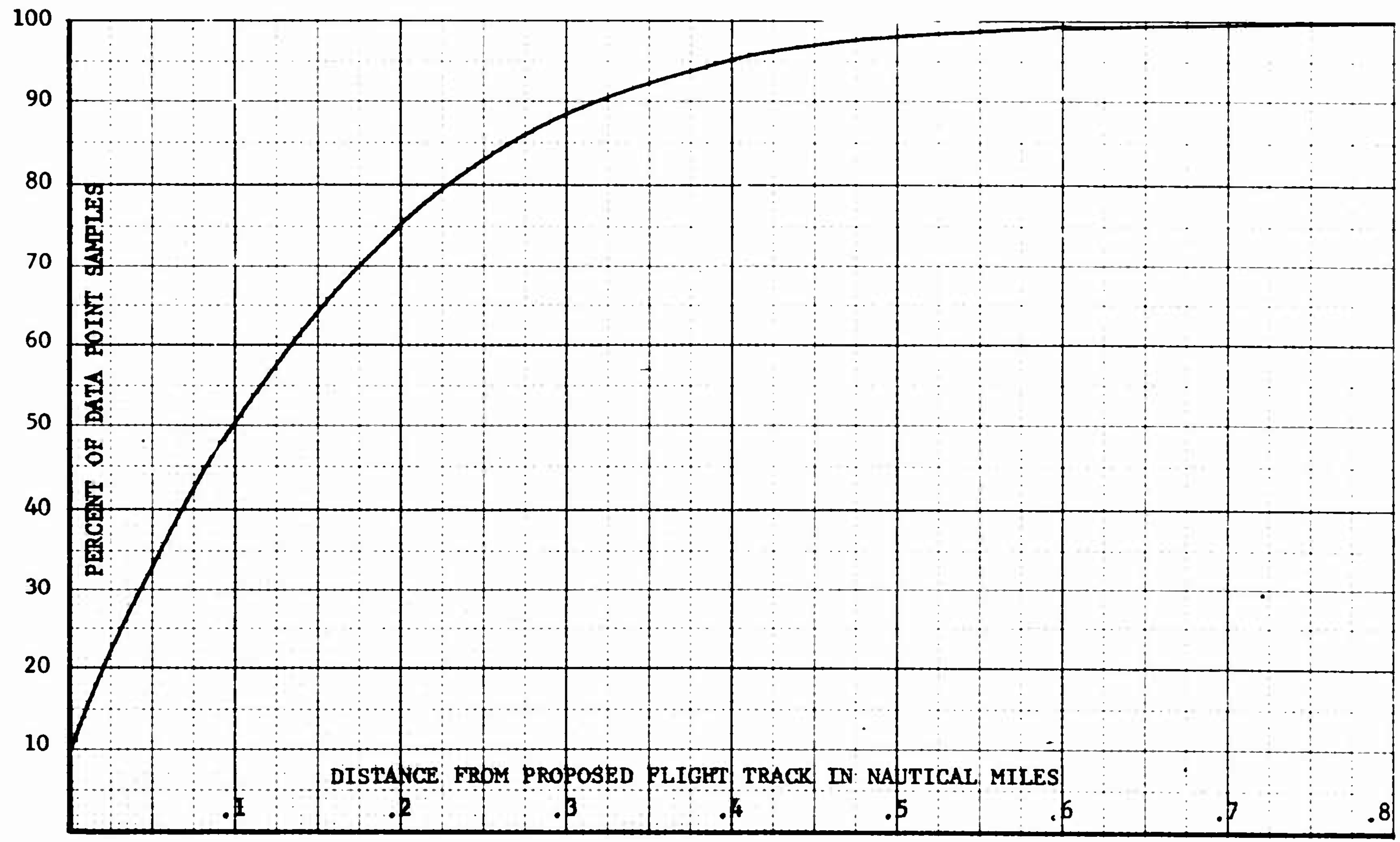


FIGURE 5. Cumulative Distribution of Beacon Digitizer Data Points.

CONCLUSIONS AND RECOMMENDATIONS

The following observations are made based upon the evaluation of the Breguet 941 aircraft in the Northeast Corridor terminal area demonstration:

Turning Radii. The turning radius for 80 knots with a 15 degree bank angle used in the development of the departure routes and holding patterns appears essentially correct for use as a minimum standard. For further application, the formula:

$$R = \frac{V^2}{g \tan \theta \text{ bank angle}}$$

is recommended as a universally accepted formula for aircraft turning radii.

Route Segments. The route segment lengths will be dictated in part by the function for which they are established. The longest route segment to be considered in the terminal area should be the segment from the Initial Approach Fix (IAF) to the Final Approach Fix (FAF). Care should be taken in the establishment of short length segments when turns are required at the end of the previous segment. These limitations will vary depending upon whether an automatic switching system or a manual reference system is used to progress from one course to the next. Not enough samples of unsatisfactory segment lengths were gathered on this project to identify the actual limitations. However, it was seen that 7000 feet is insufficient distance between way-points if turns exceeding 60 degrees are involved, and 9000 feet is satisfactory with turns up to 90 degrees.

Flight Accuracy. The flight accuracy demonstrated on this project seems to indicate that the obstacle protected width of terminal area route segments could be reduced for STOL operations. Further evaluation with various types of STOL aircraft and with a statistically acceptable number of data samples should be completed prior to the establishment of specific route widths.

APPENDIX 1

PROJECT AUTHORIZATION/STATUS

1. PROJECT TITLE	2. PROJECT NO.
Evaluation of the MDC/EAL Northeast Corridor STOL Demonstration	68-460-3

3. PROJECT SUMMARY (Origin, objective, impact on regulations/directives, etc.)

Provide data collection, reduction, and analysis service during the proposed MDC/EAL Northeast Corridor STOL demonstration. Aircraft position data is required for those flights occurring during Phase III of the demonstration to be conducted during the months of September and October of 1968 along the Eastern shuttle routes and in the New York metropolitan area.

This information, if properly coordinated with proposed Eastern airborne data recording, will provide a valuable independently derived tool for assessing the possibility of new airway concepts and separation standards for STOL aircraft.

(Continued on backside)

4. ESTIMATED MANHOURS	5. PRIORITY	6. STARTING DATE	7. COMPLETION DATE
350 (FS-460) 3500 (FS-640)	A	September 1968	July 1969

8. PROJECT OFFICER	9. SIGNATURE AND TITLE OF ORIGINATOR
G. Gibson/B.B.Bryant	Harold W. McFrich, Chief, Air Proc Stand Br

10. AUTHORIZATION	11. APPROVAL ~~REGULATORY PROJECTS ONLY~~
A. DATE 8/9/68	A. DATE 8-20-68
B. SIGNATURE OF APPROVING OFFICIAL J. A. Ferrarese	B. SIGNATURE OF CHIEF, ~~REGULATIONS STAFF~~ NFIB Earl E. Blankenship

12. STATUS OF PROJECT

B. PLANNED/ACTUAL PROGRESS (O Not Completed; Ø Completed; Ø --- O Time Slip)

A. COMPONENT TASKS	1Q69	2Q69	3Q69	4Q69	
1. Prepare project outline - FS-640.	Ø				
2. Coordinate and schedule methods for data collection at New York ARTCC - FS-640.	Ø				
3. Collect and record data of actual flts. -FS-640		Ø			
4. Reduce and analyze data - FS-640.		Ø--	-Ø		
5. Submit preliminary reports - FS-640.		Ø--	-Ø		
6. Coordinate preliminary reports - FS-460.			Ø		
7. Submit final report - FS-640.			Ø		
8. Coordinate final report - FS-460.			O		
9. Coordinate and publish required standards - FS-460				O	

FS 1800-4 (4-68) SUPERSEDES FAA FORM 3552 (TEST) AND FAA FORM 3553 (TEST)

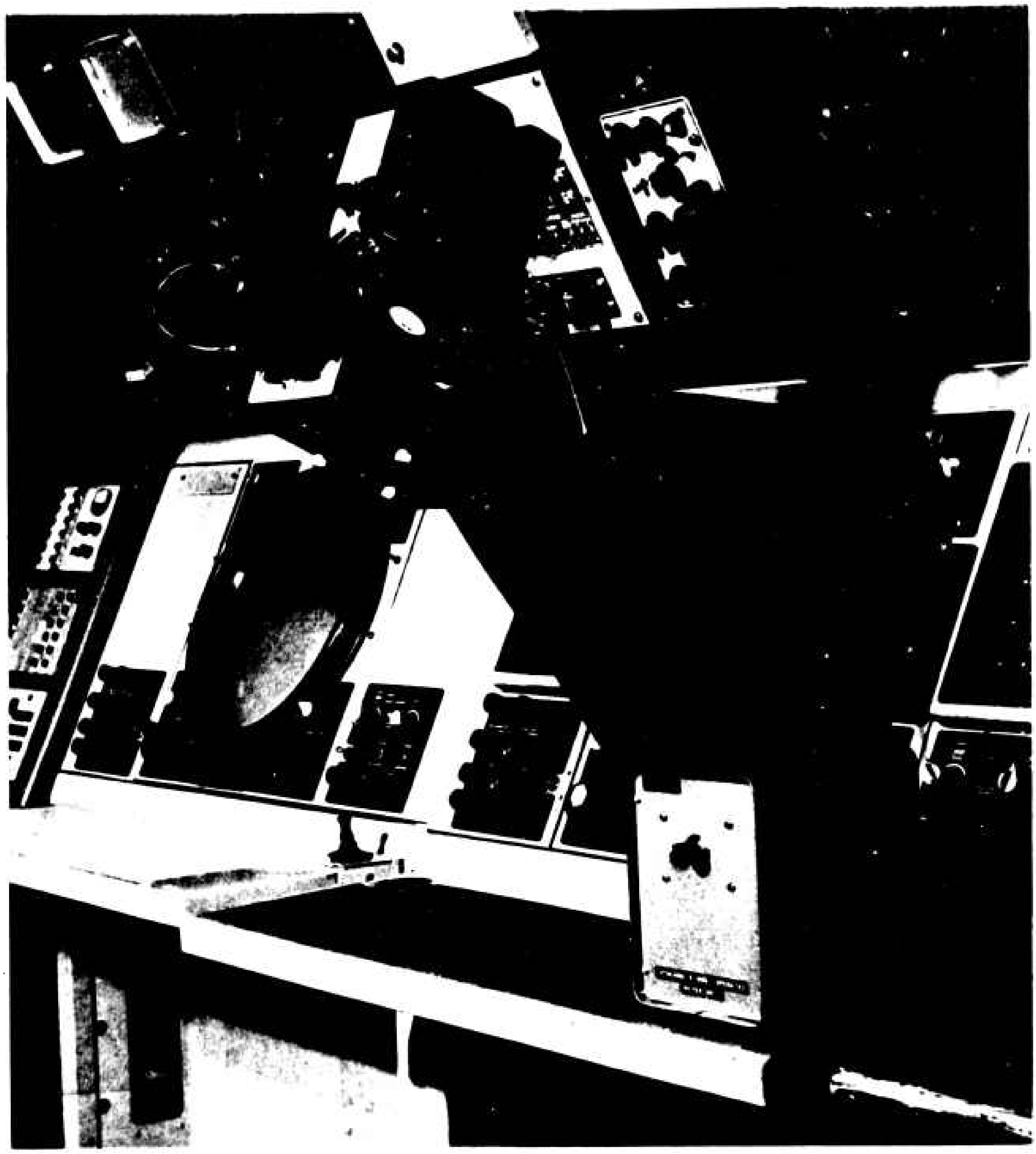


FIGURE 6. Data Camera Installation.

FIGURE 7. Typical Photo Frame from Data Camera.

FIGURE 8. Aircrew and Technicians Assigned to Demonstrate Breguet 941 STOL

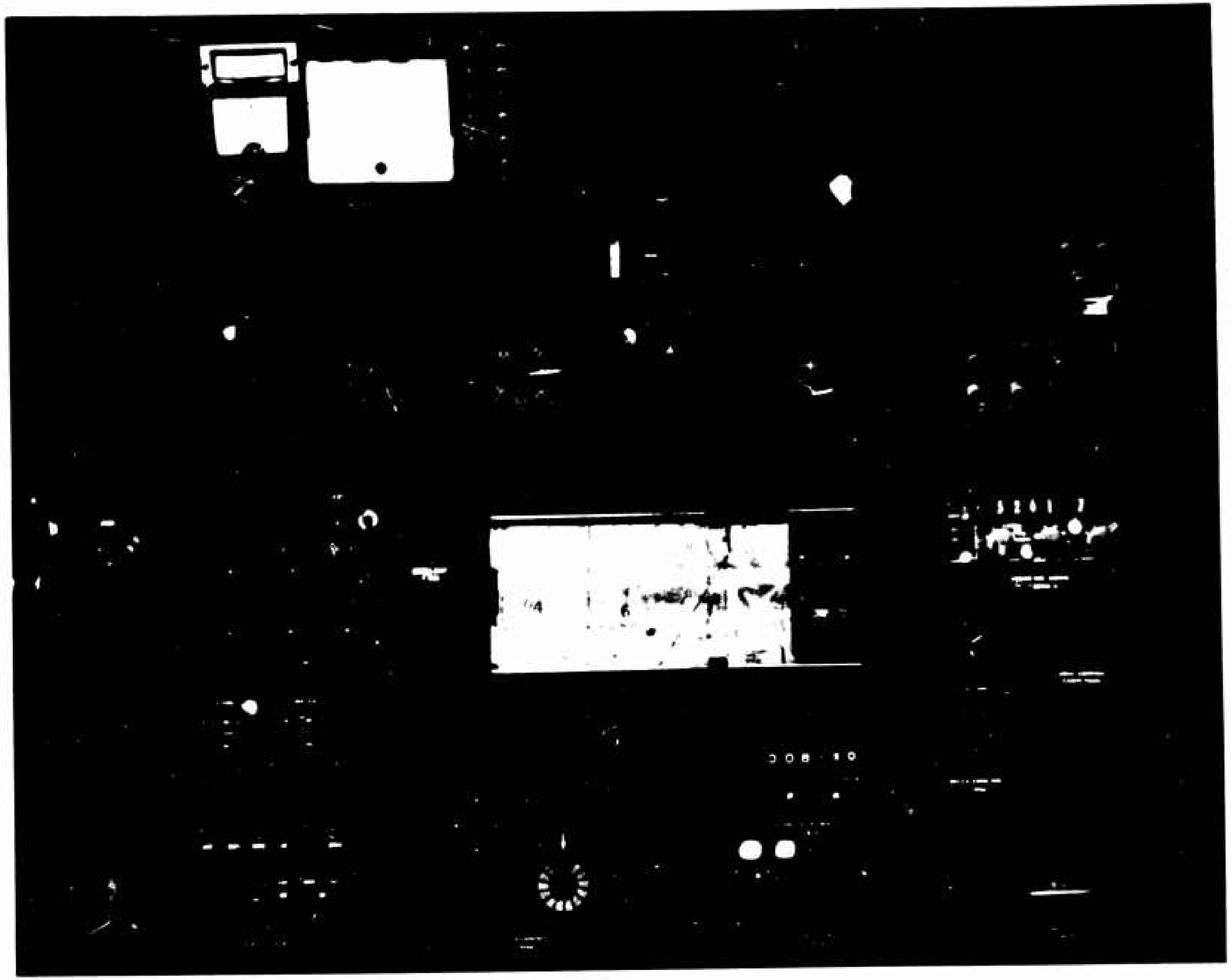


FIGURE 9. Decca Omnitrac Console in MDC 188 STOL Aircraft

FIGURE 10. Map of STOL Routes in New York City Area.

APPENDIX 2

Figures 9 through 98 portray those Decca Omnitrac Charts which were used in measuring the distance between the Beacon Digitizer position coordinates and the proposed flight track.

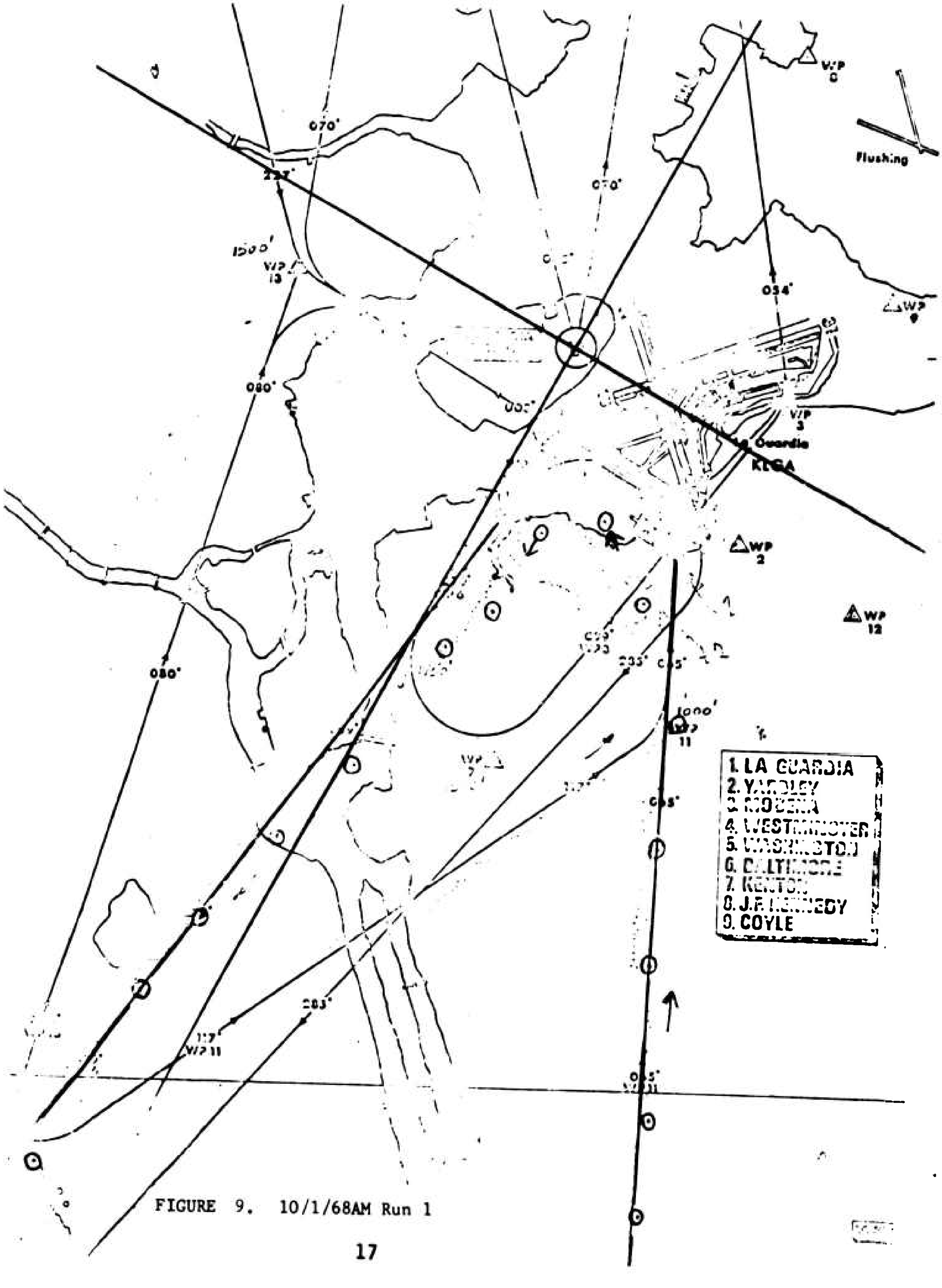


FIGURE 9. 10/1/68AM Run 1

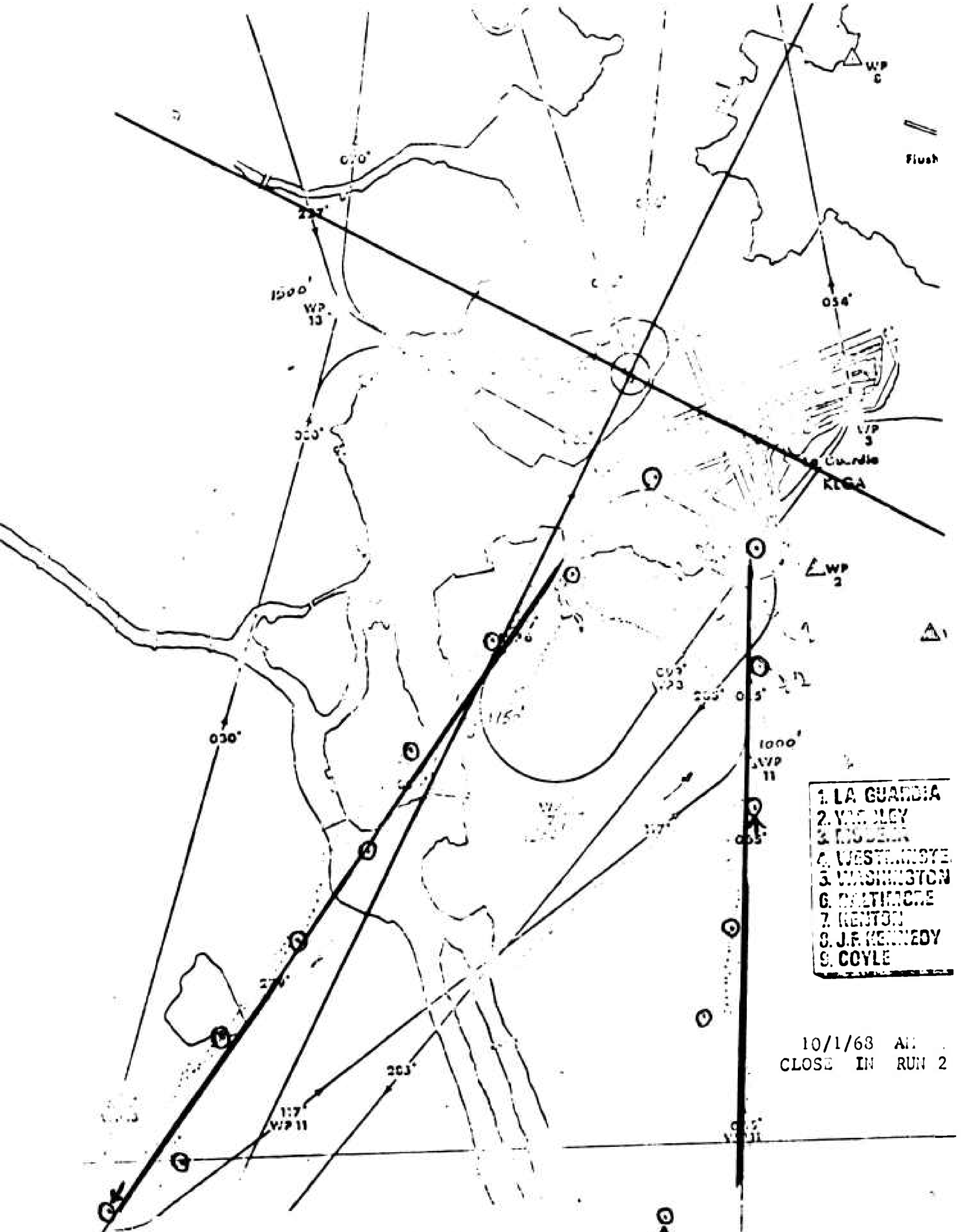


FIGURE 10. 10/1/68AM Run 2

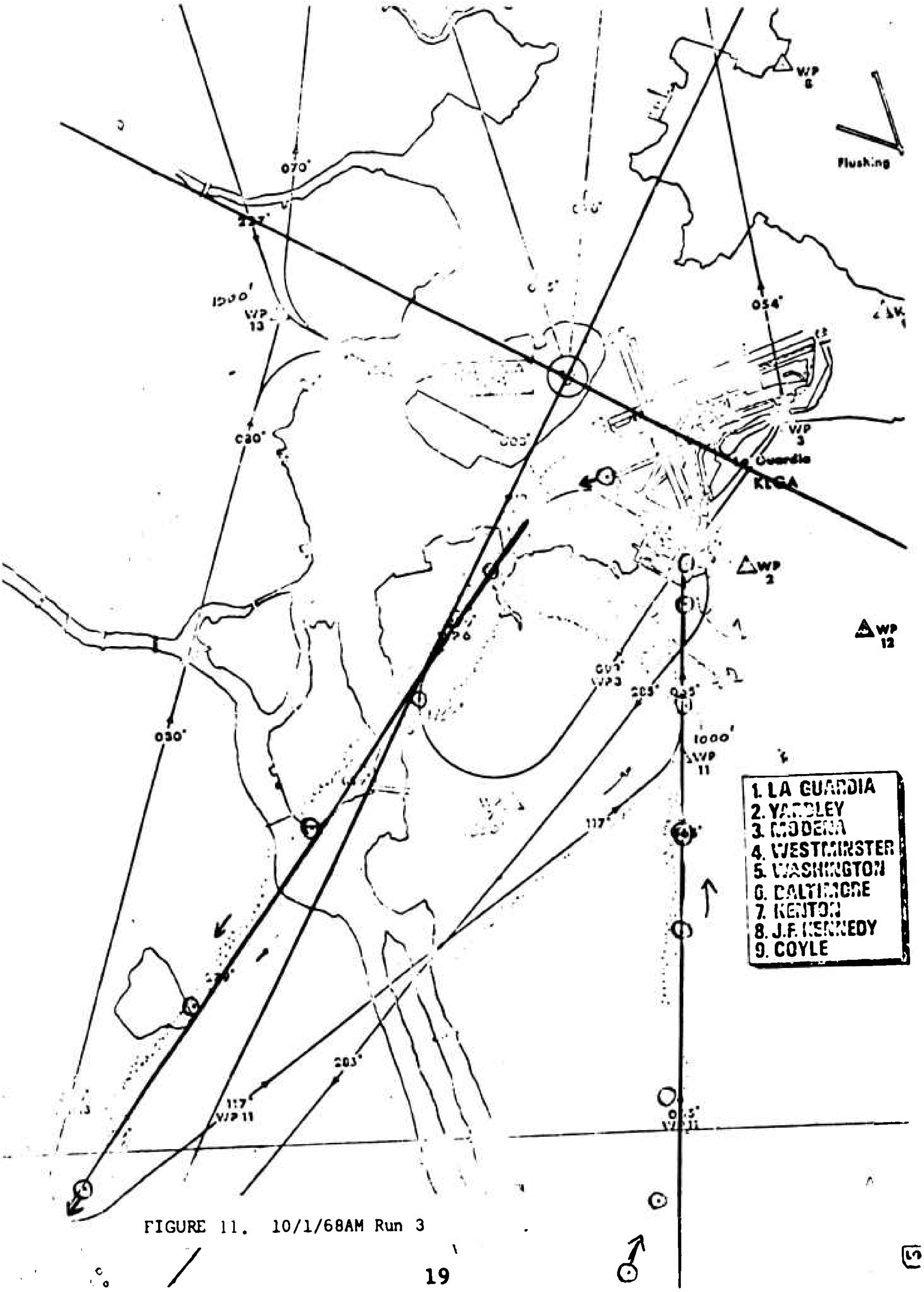


FIGURE 11. 10/1/68AM Run 3

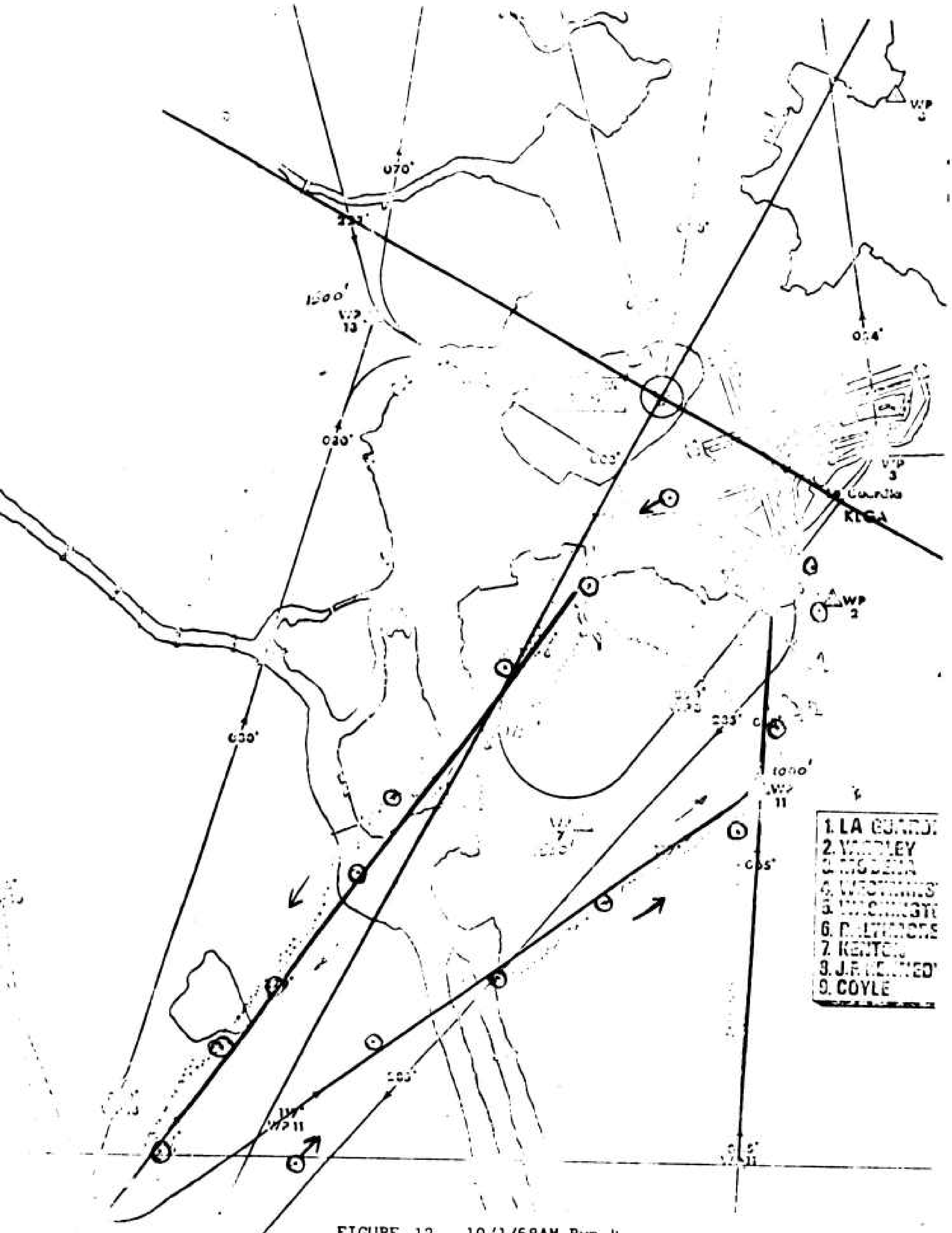


FIGURE 12. 10/1/68AM Run 4

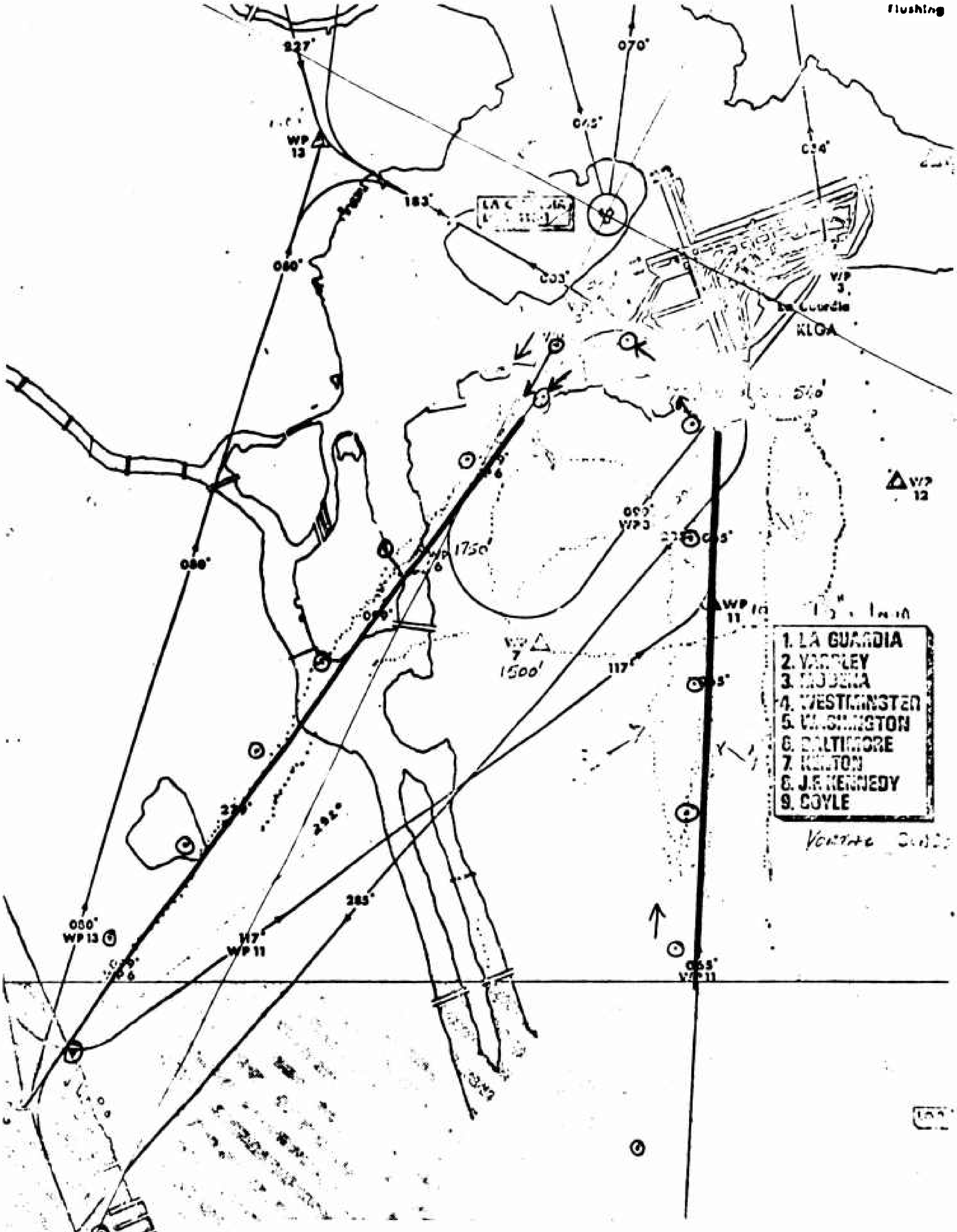


FIGURE 13. 10/1/68PM Run 1

026T

11°W X-42 YTOW YB-18

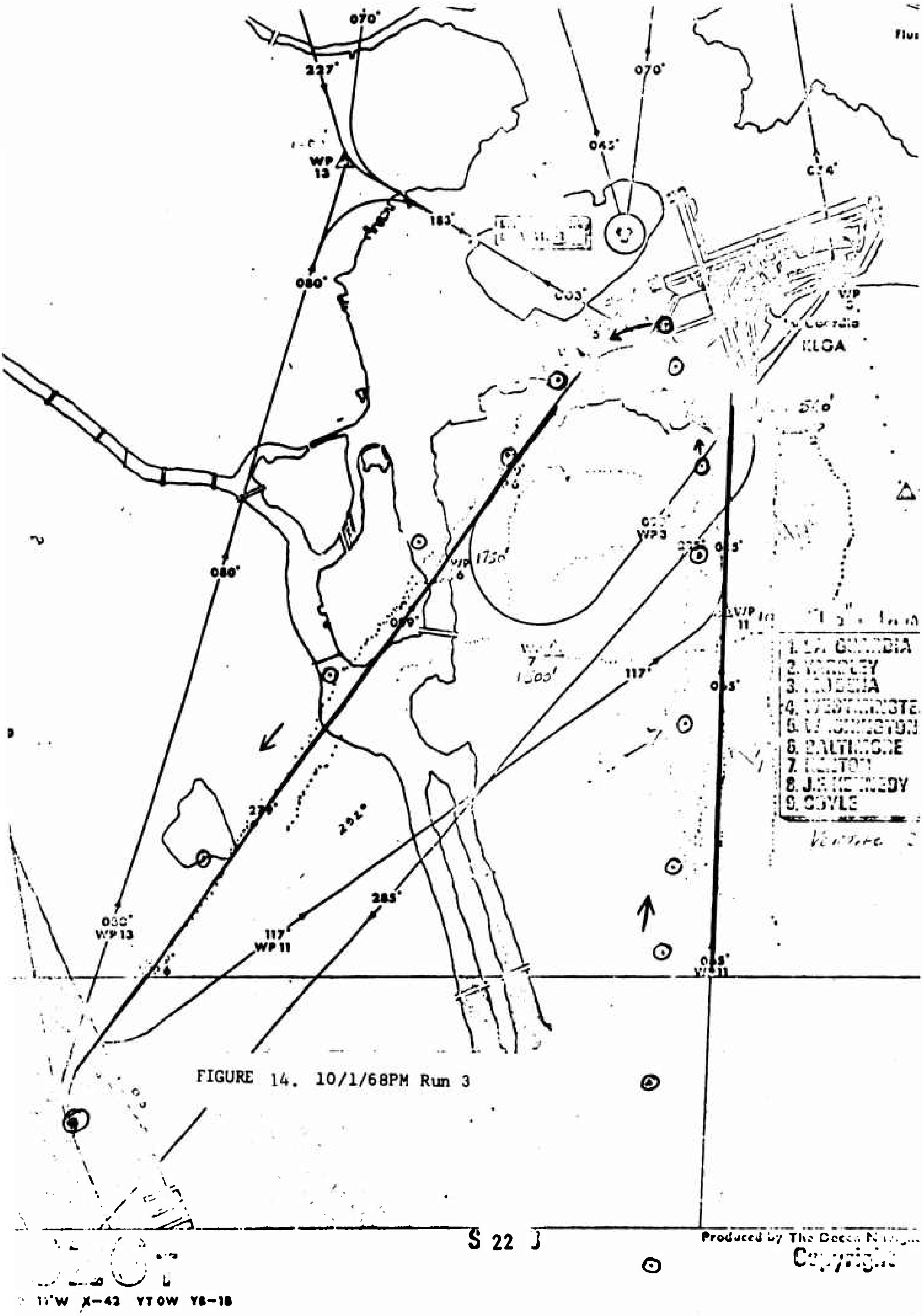


FIGURE 14. 10/1/68PM Run 3

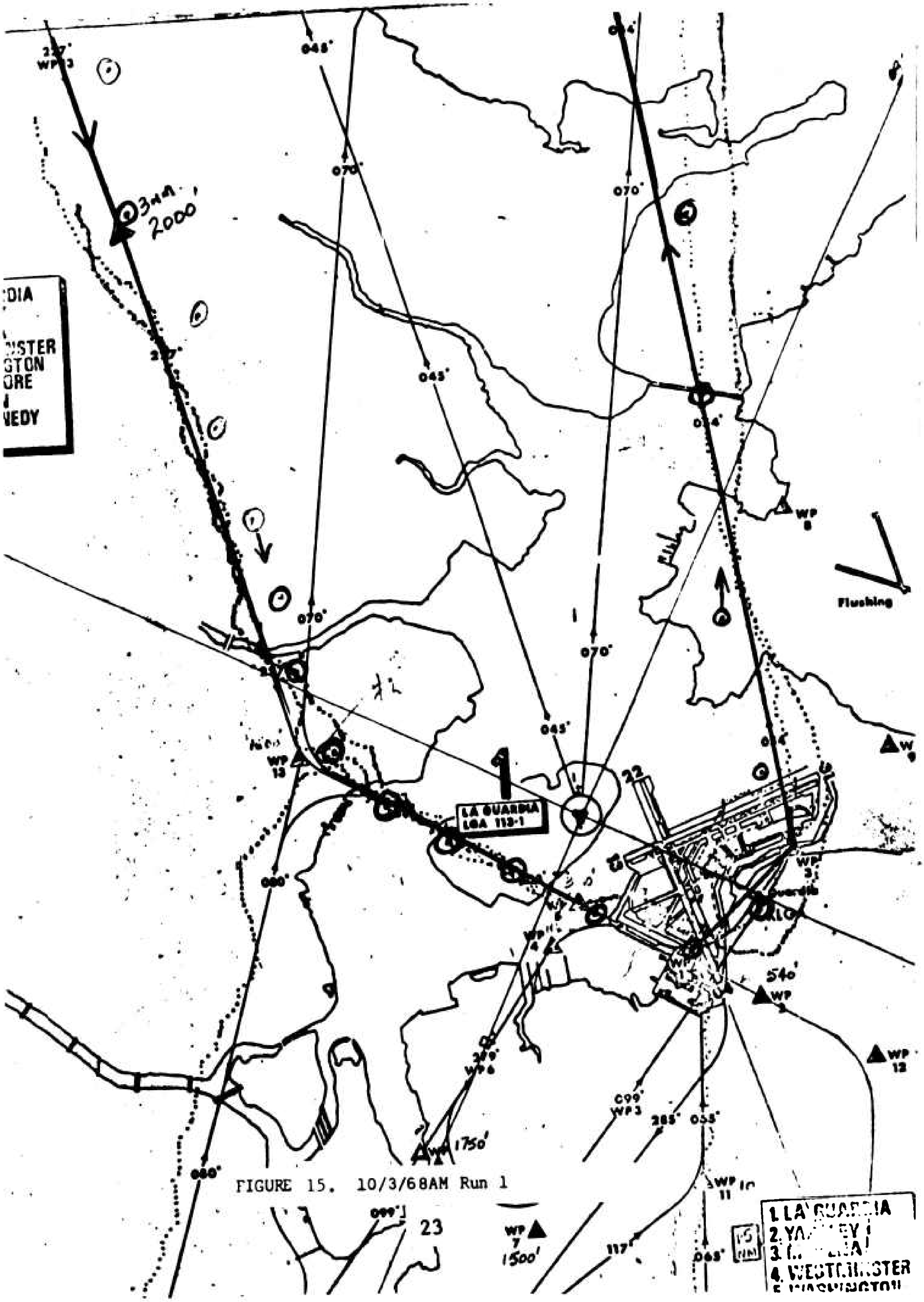


FIGURE 15. 10/3/68AM Run 1

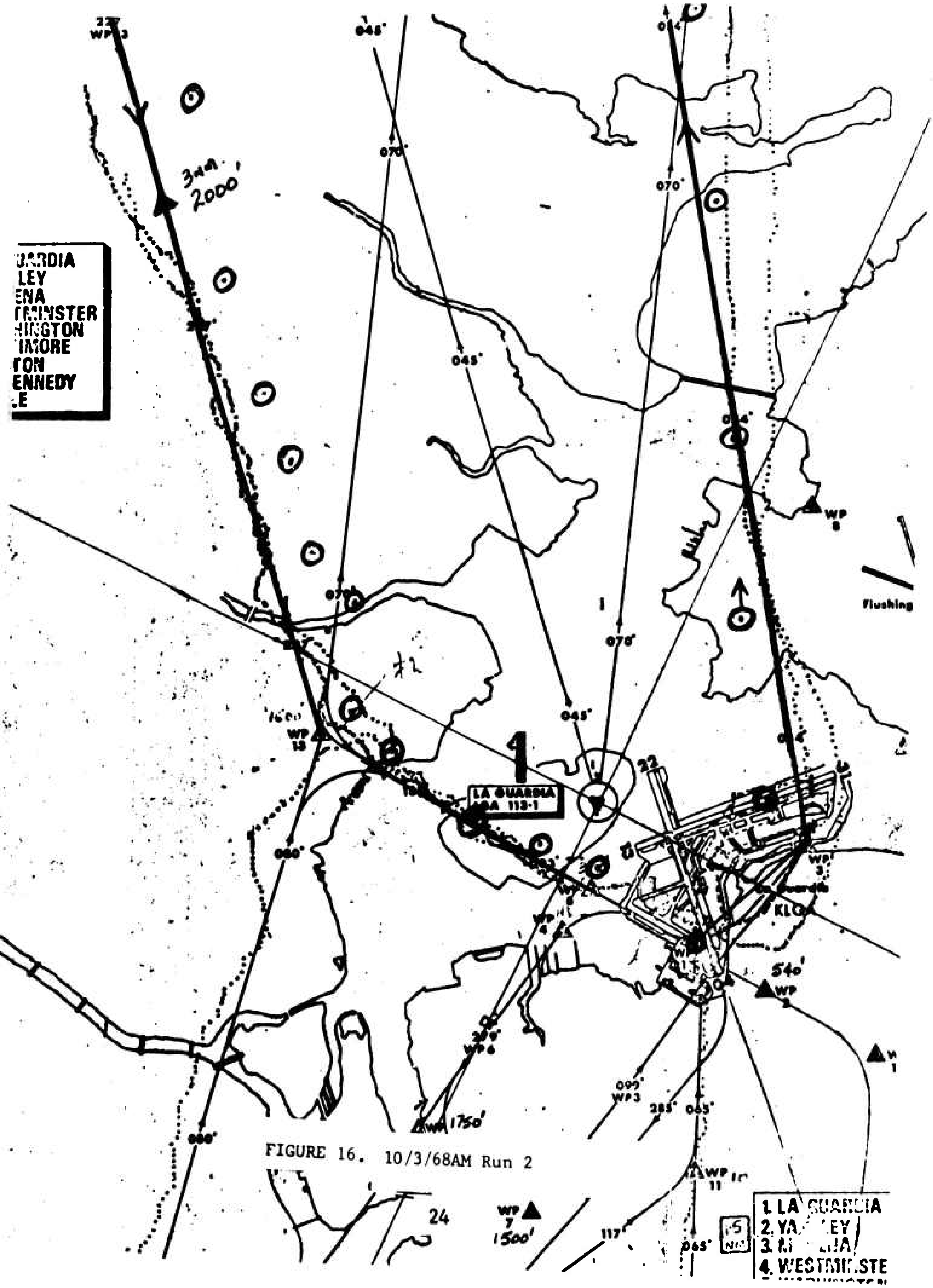


FIGURE 16. 10/3/68AM Run 2

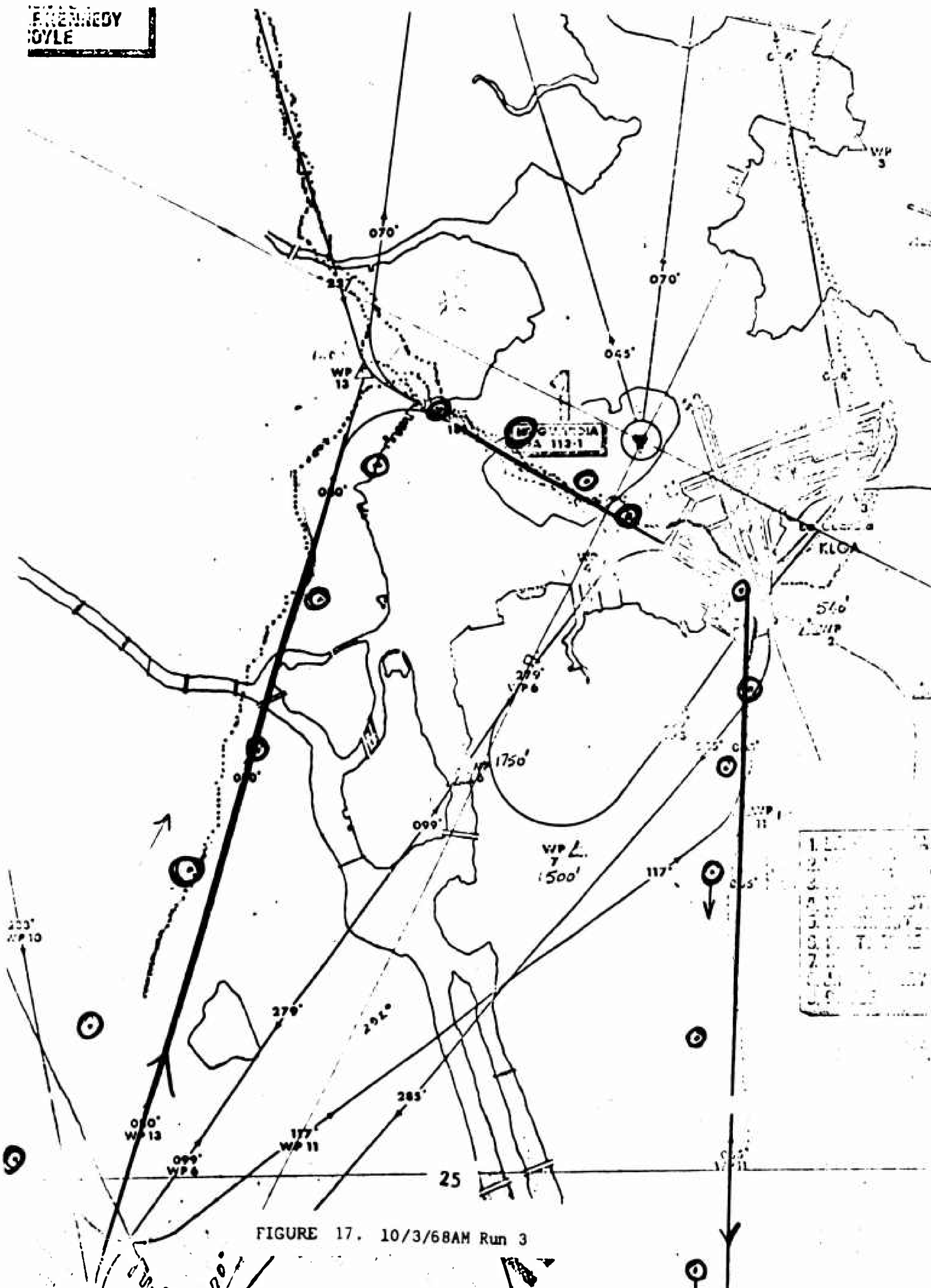


FIGURE 17. 10/3/68AM Run 3

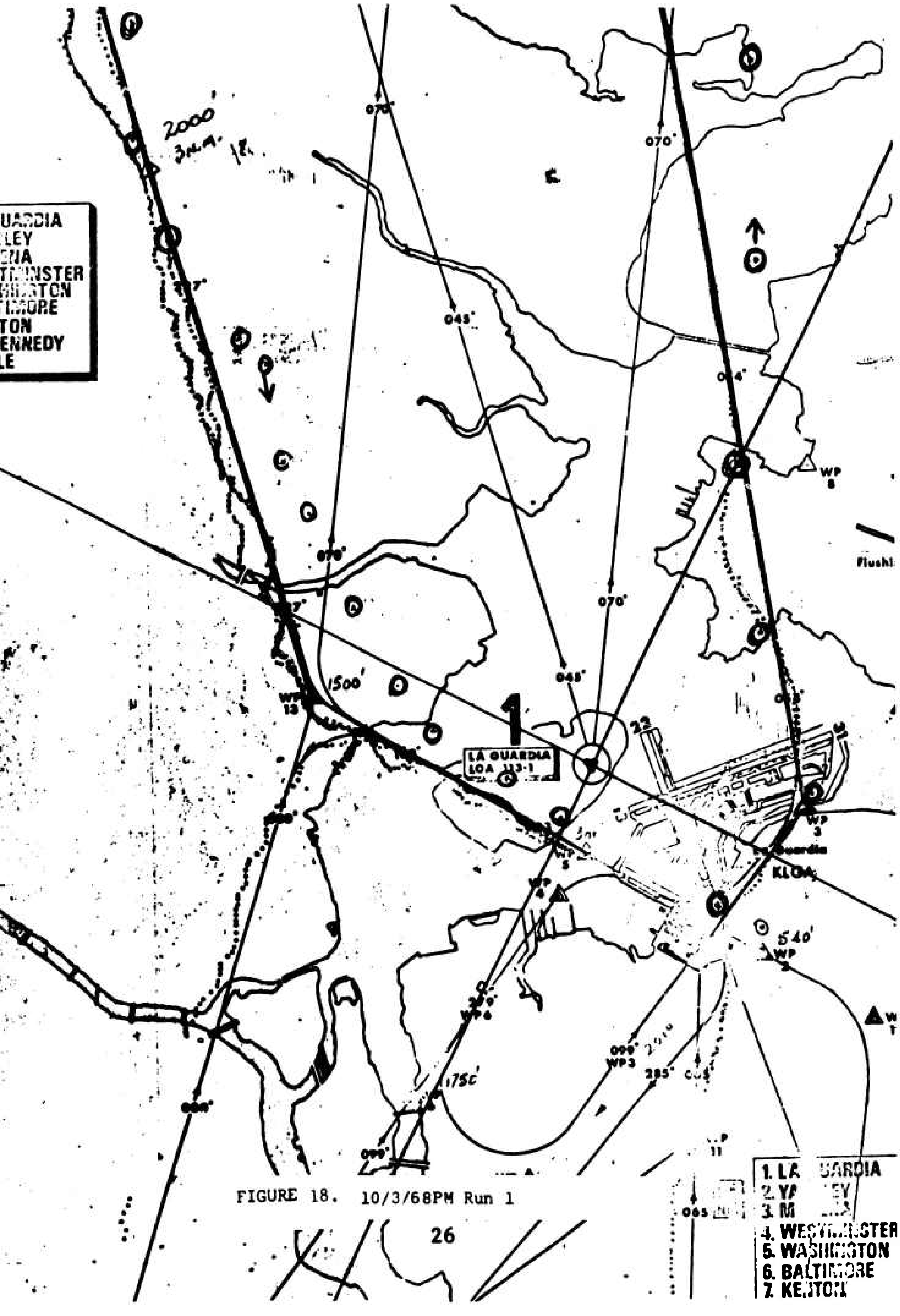


FIGURE 18. 10/3/68PM Run 1

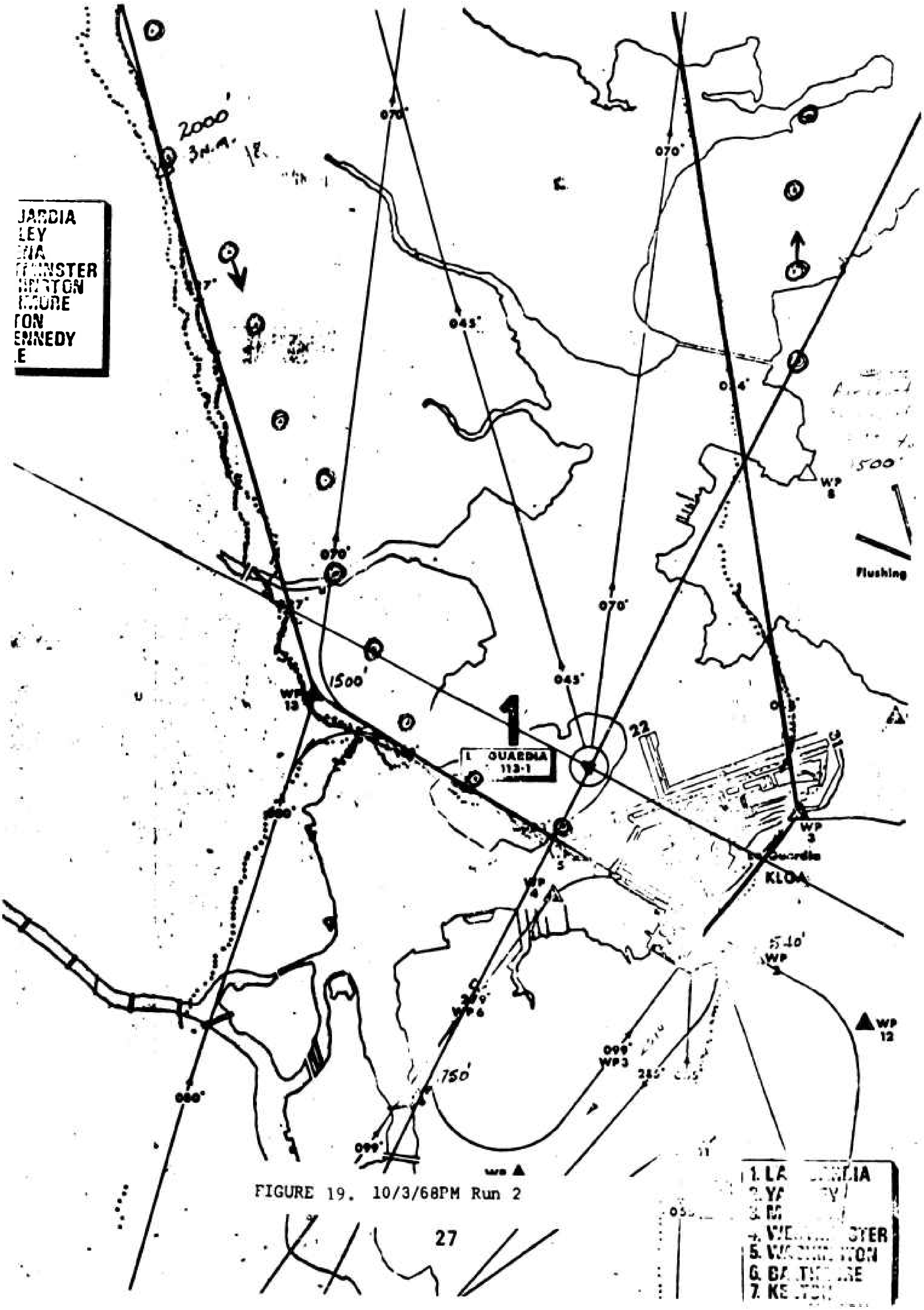


FIGURE 19. 10/3/68PM Run 2

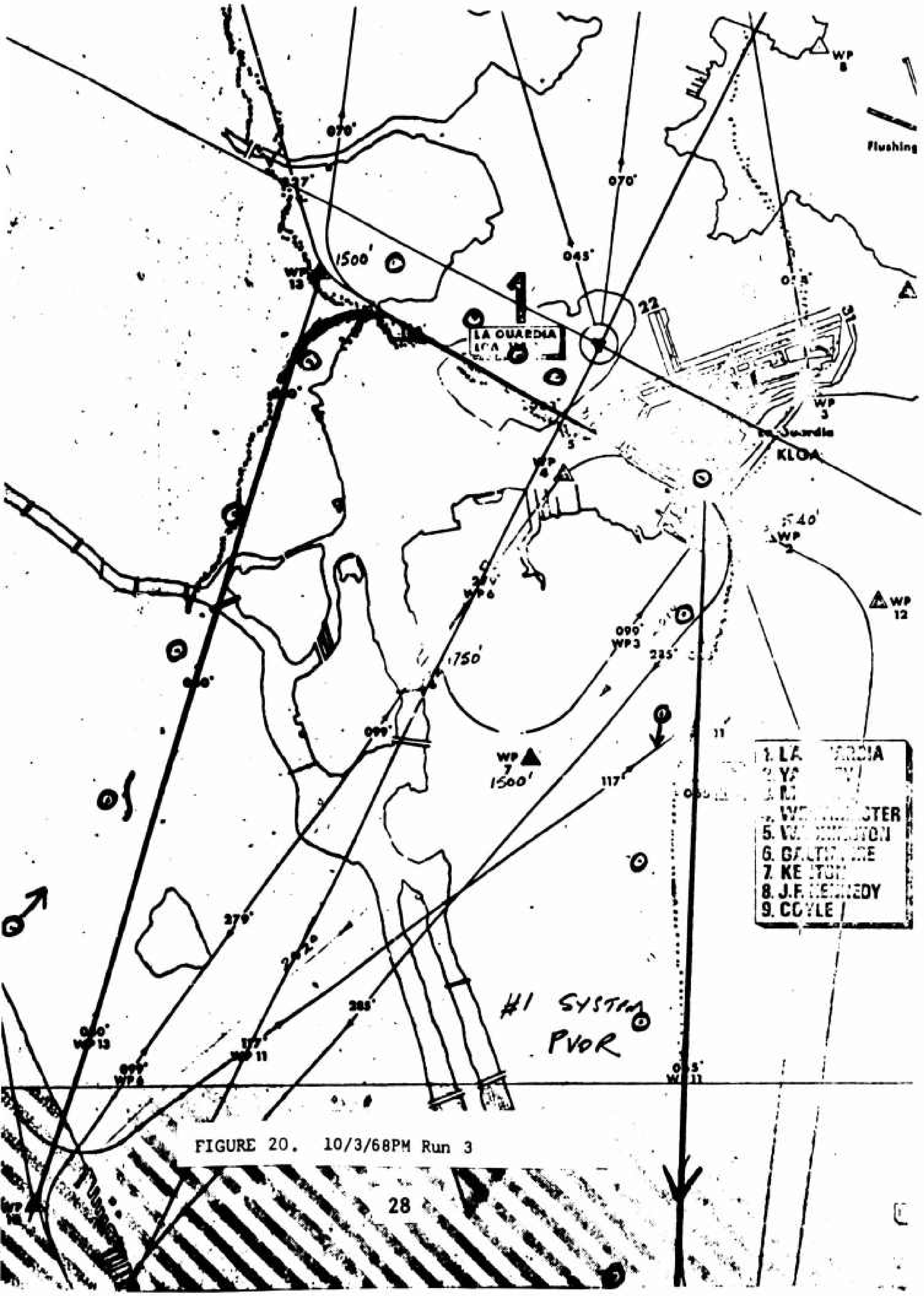


FIGURE 20. 10/3/68PM Run 3

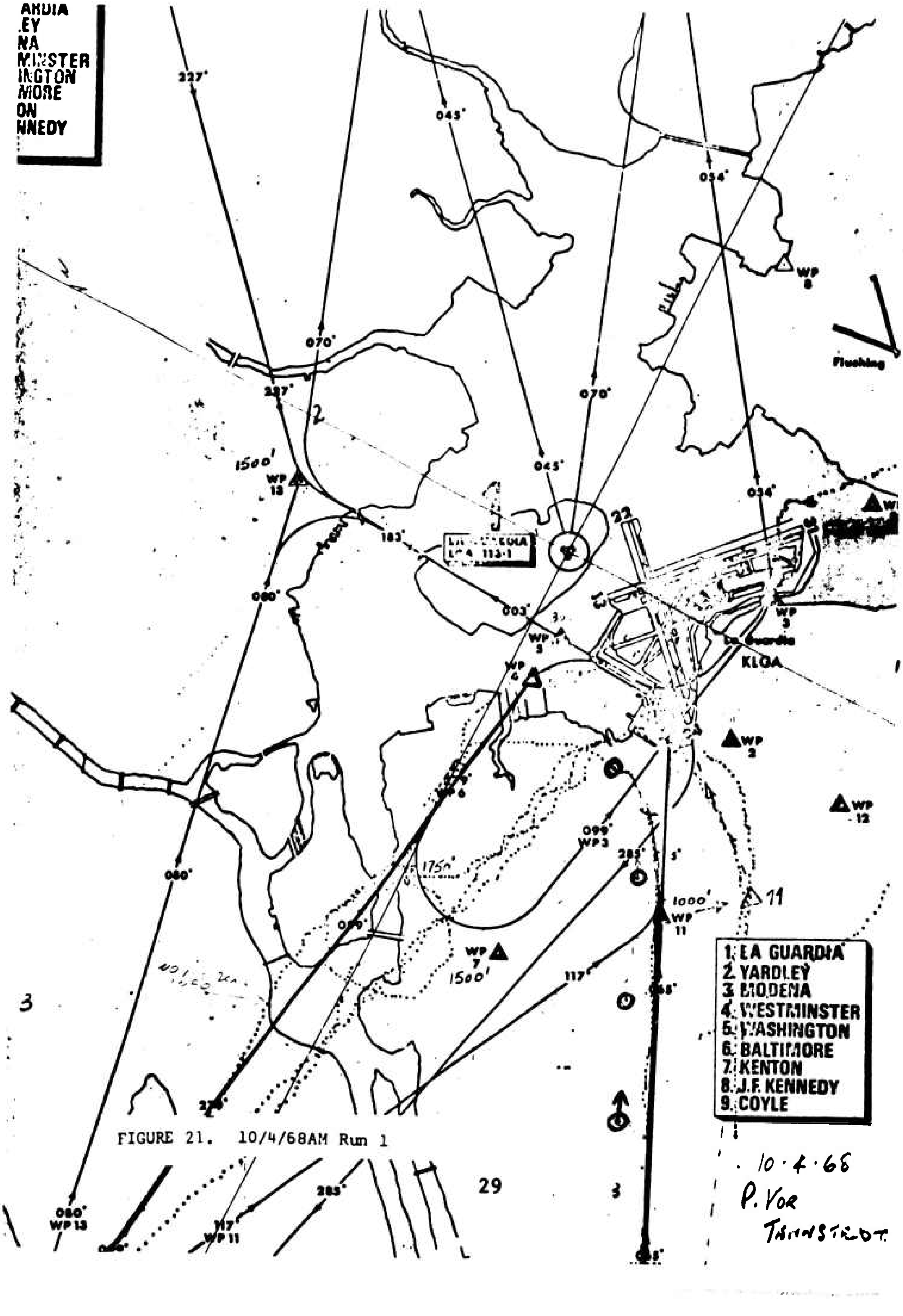


FIGURE 21. 10/4/68AM Run 1

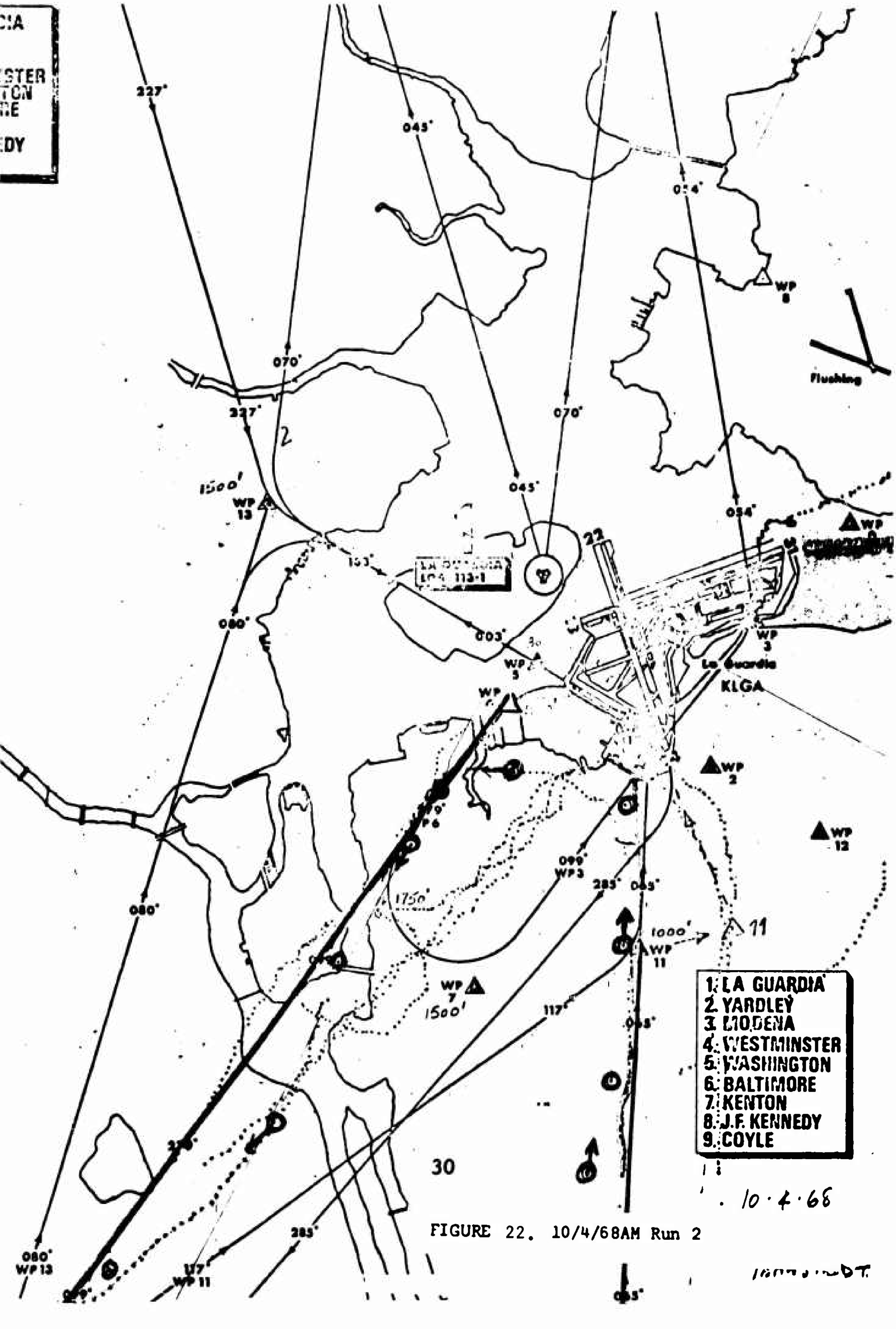


FIGURE 22. 10/4/68AM Run 2

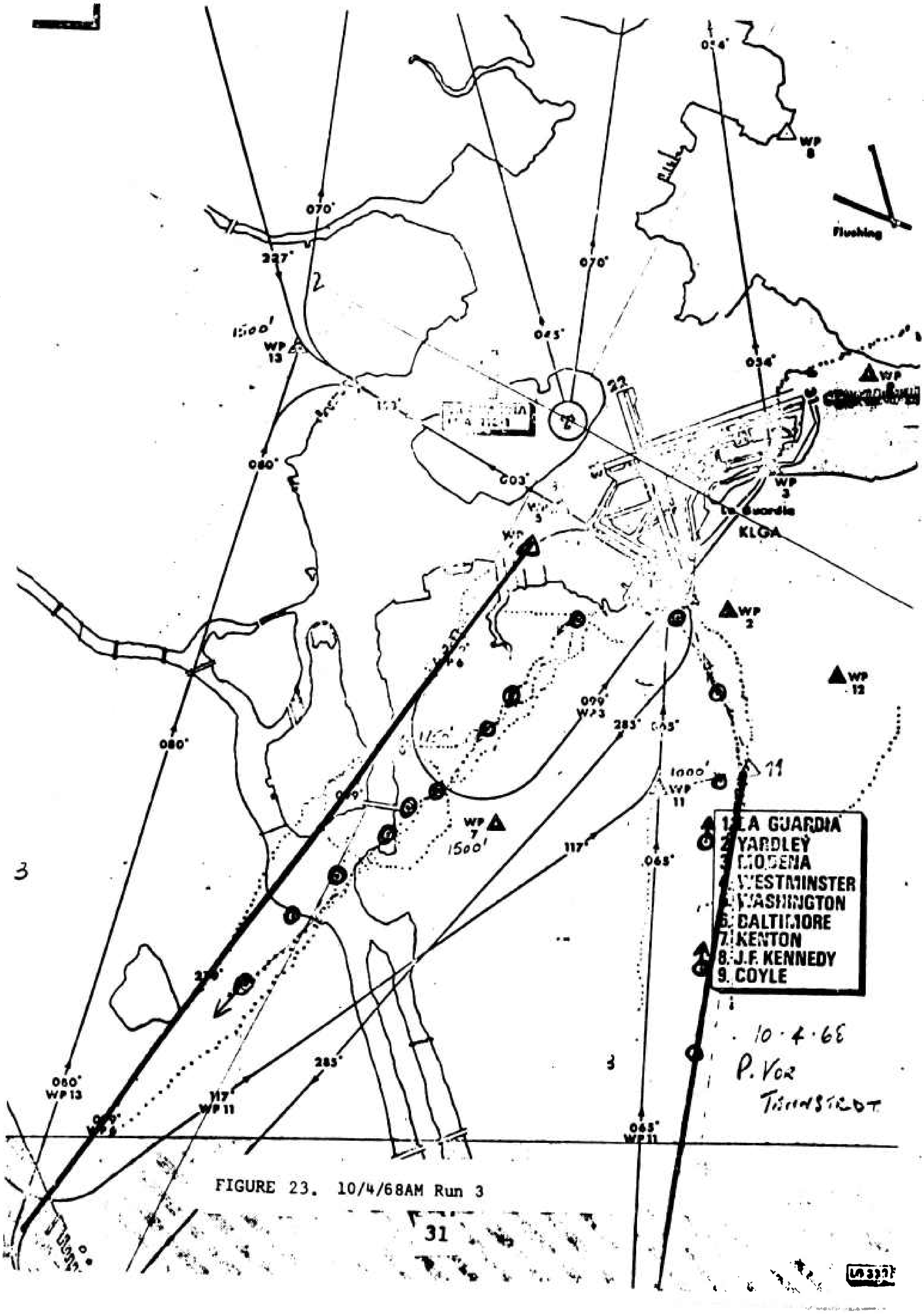


FIGURE 23. 10/4/68AM Run 3

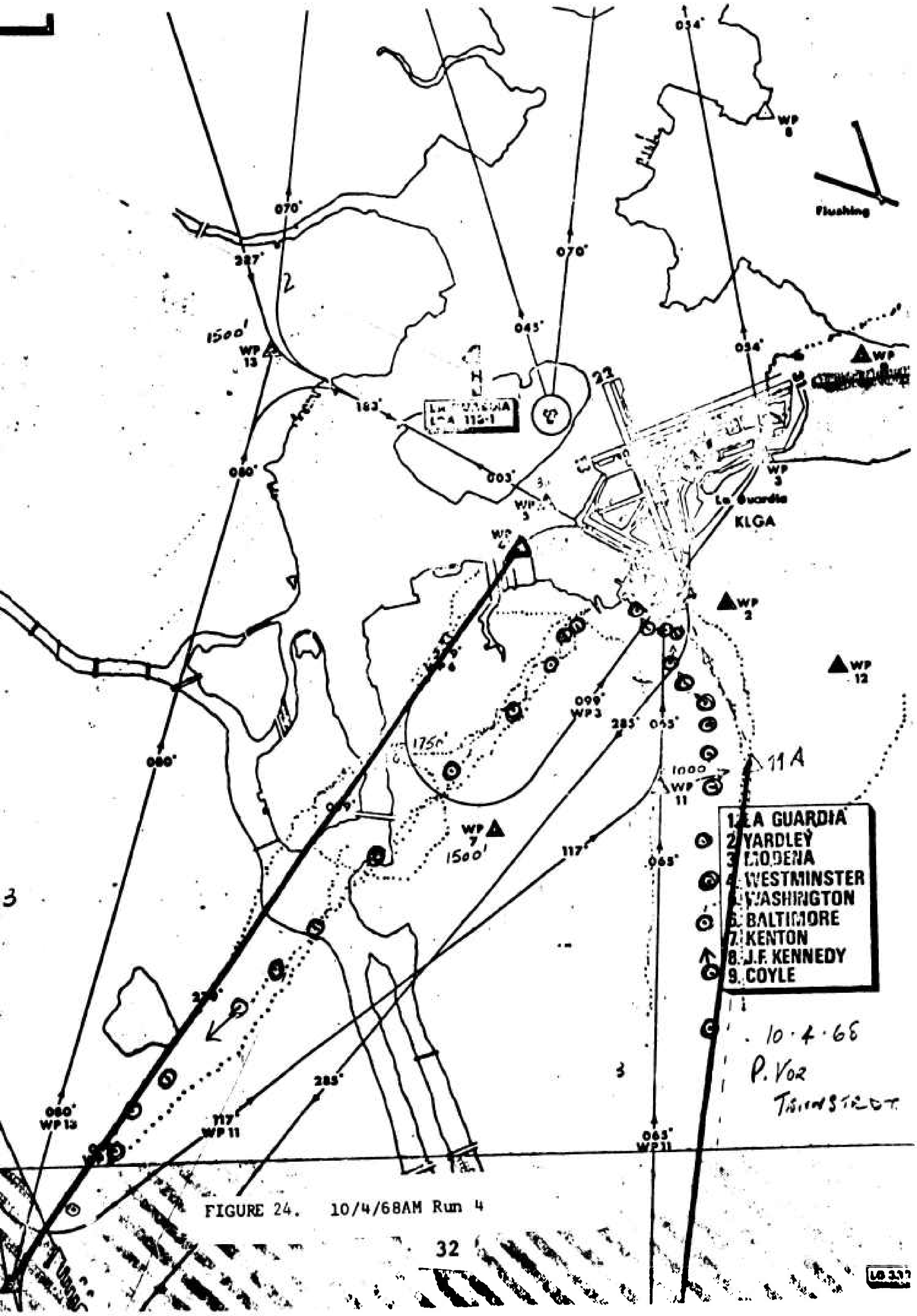


FIGURE 24. 10/4/68AM Run 4

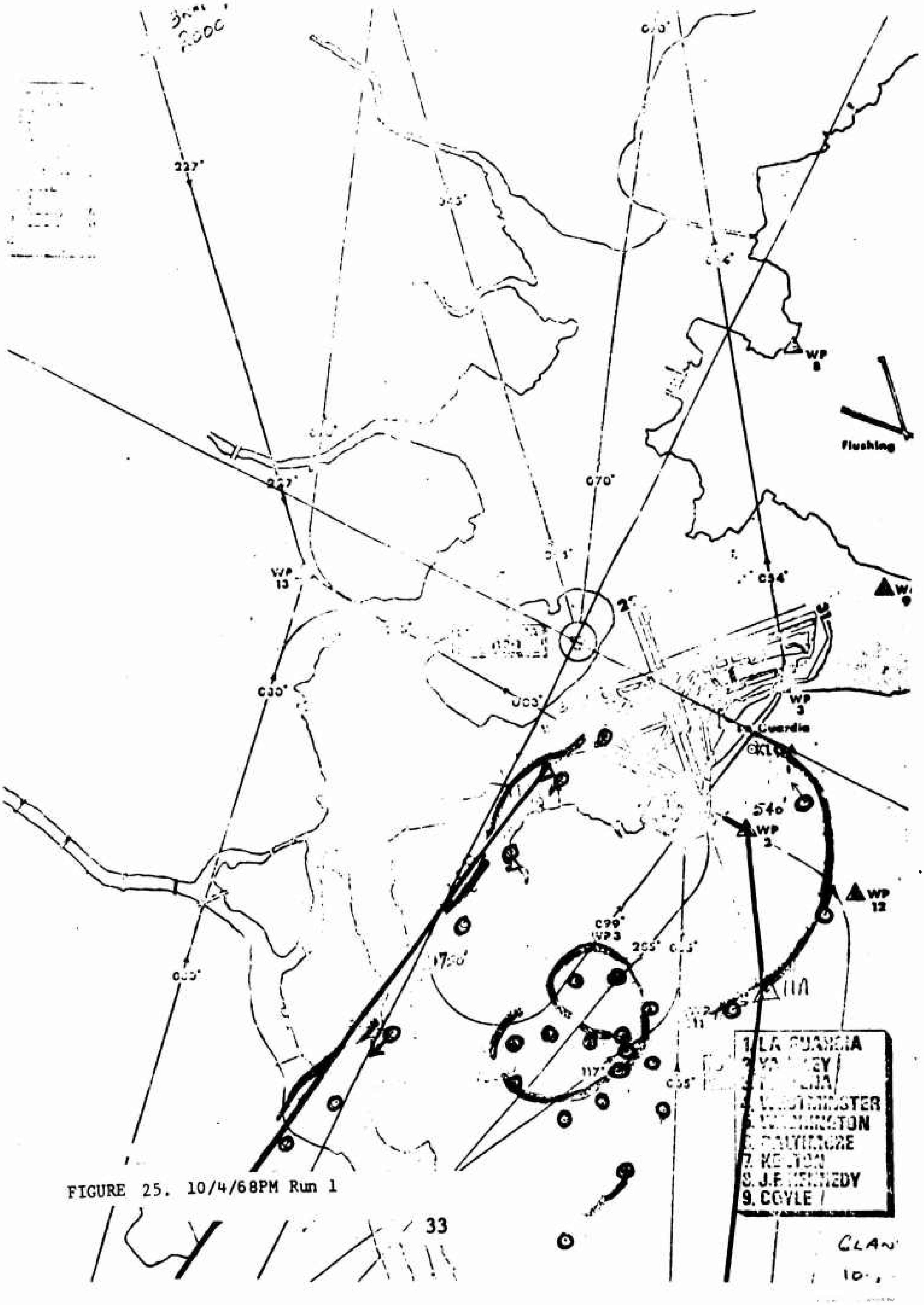


FIGURE 25. 10/4/68PM Run 1

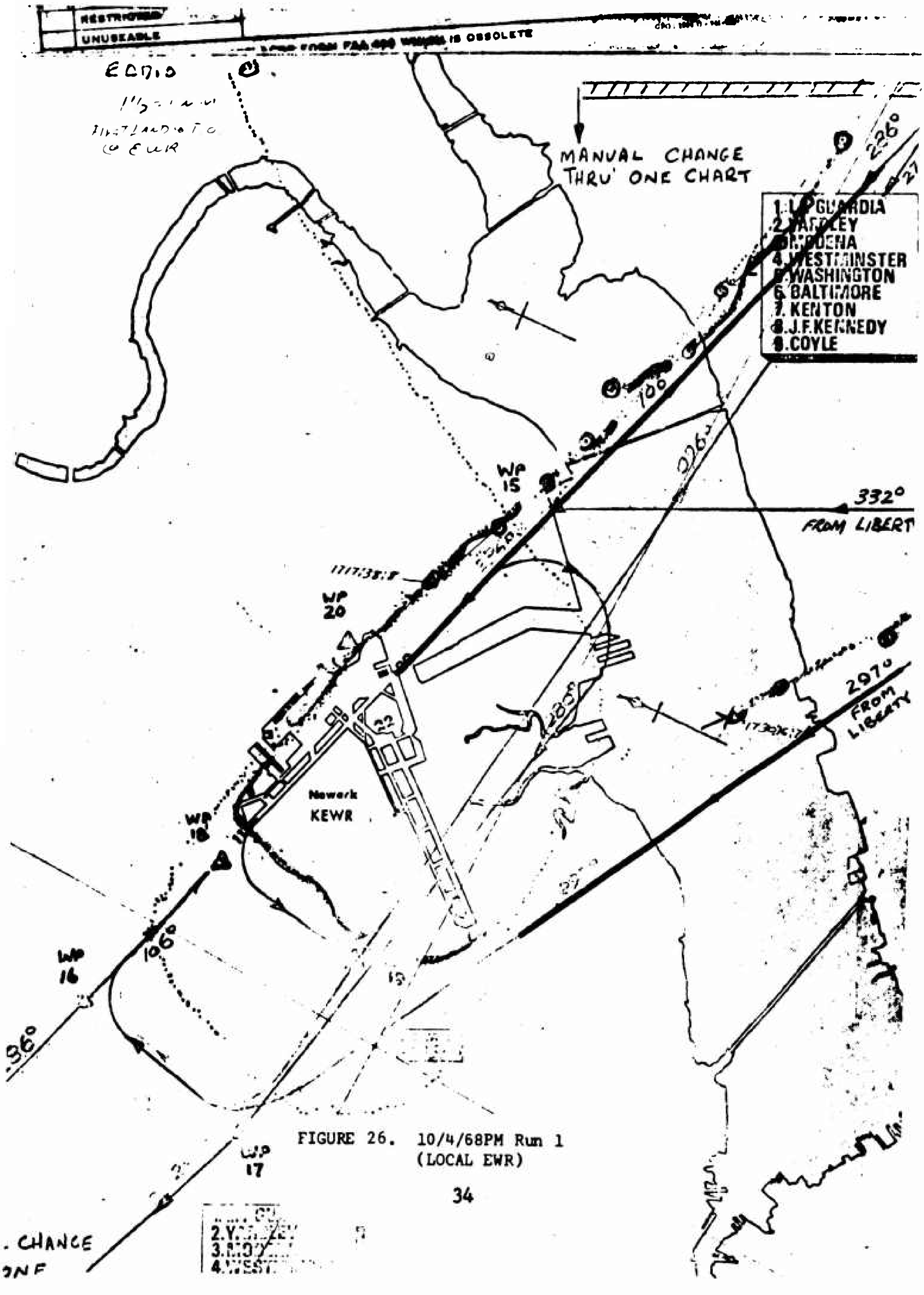


FIGURE 26. 10/4/68PM Run 1
(LOCAL EWR)

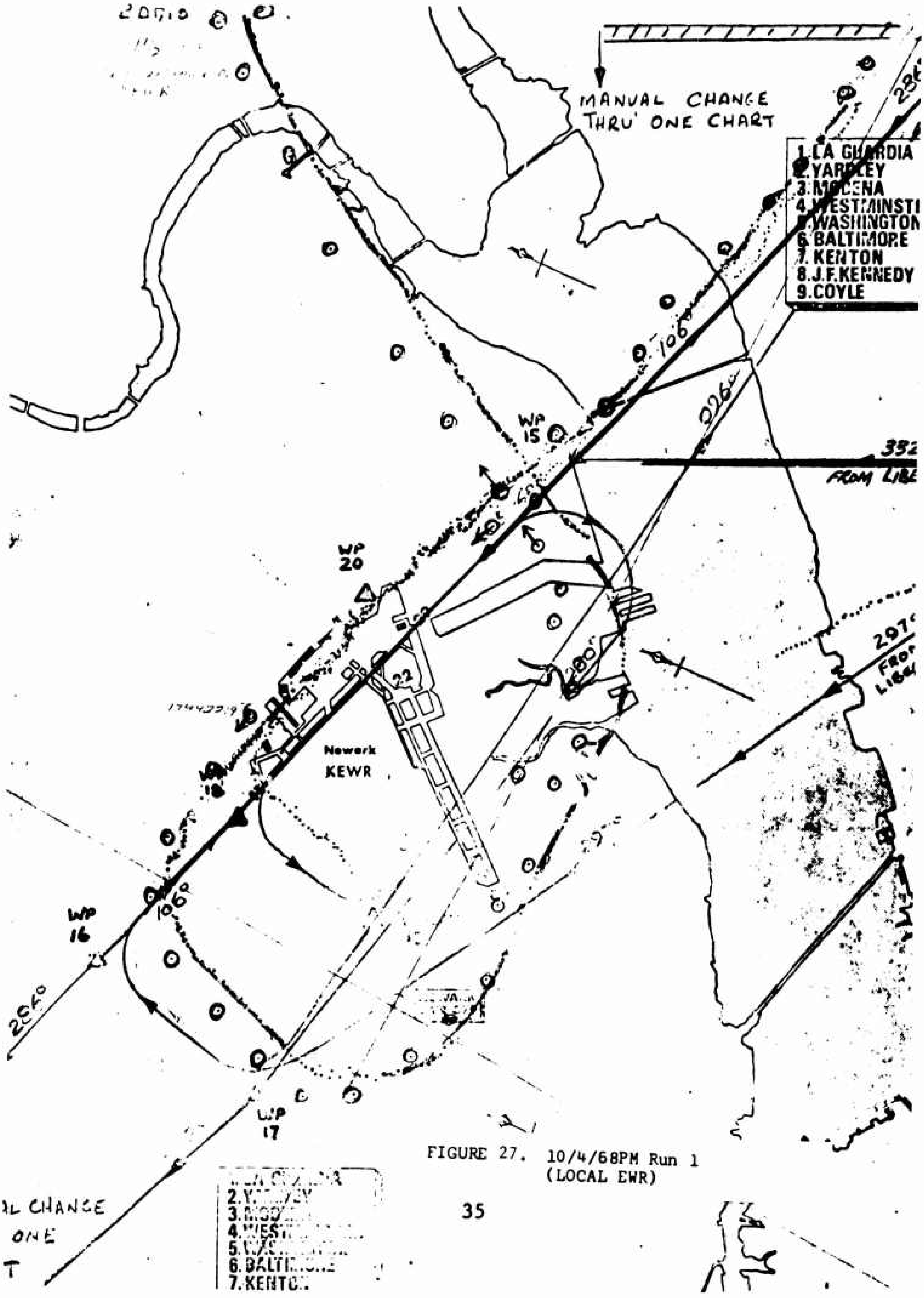


FIGURE 27. 10/4/68PM Run 1
(LOCAL EWR)

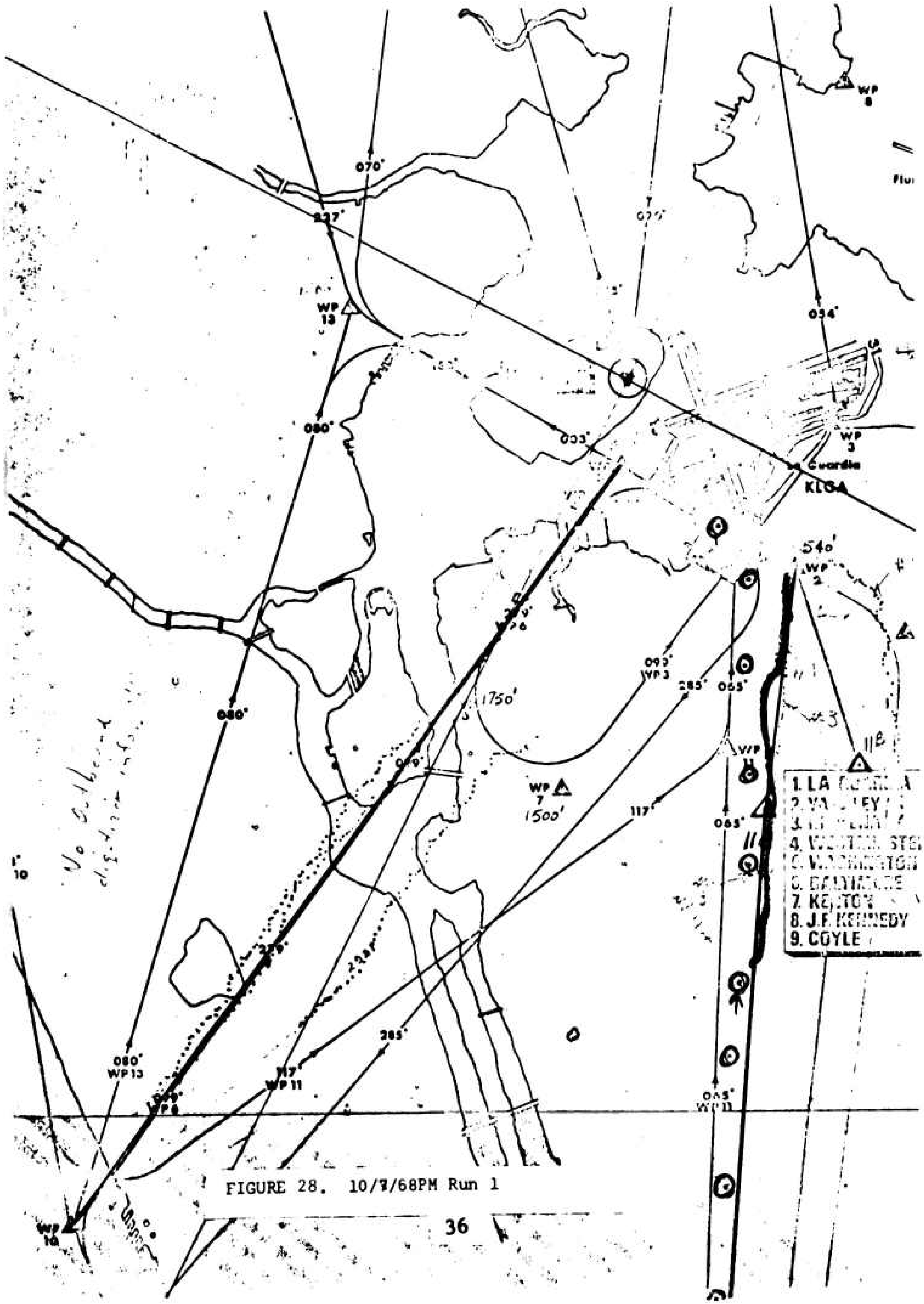


FIGURE 28. 10/7/68PM Run 1

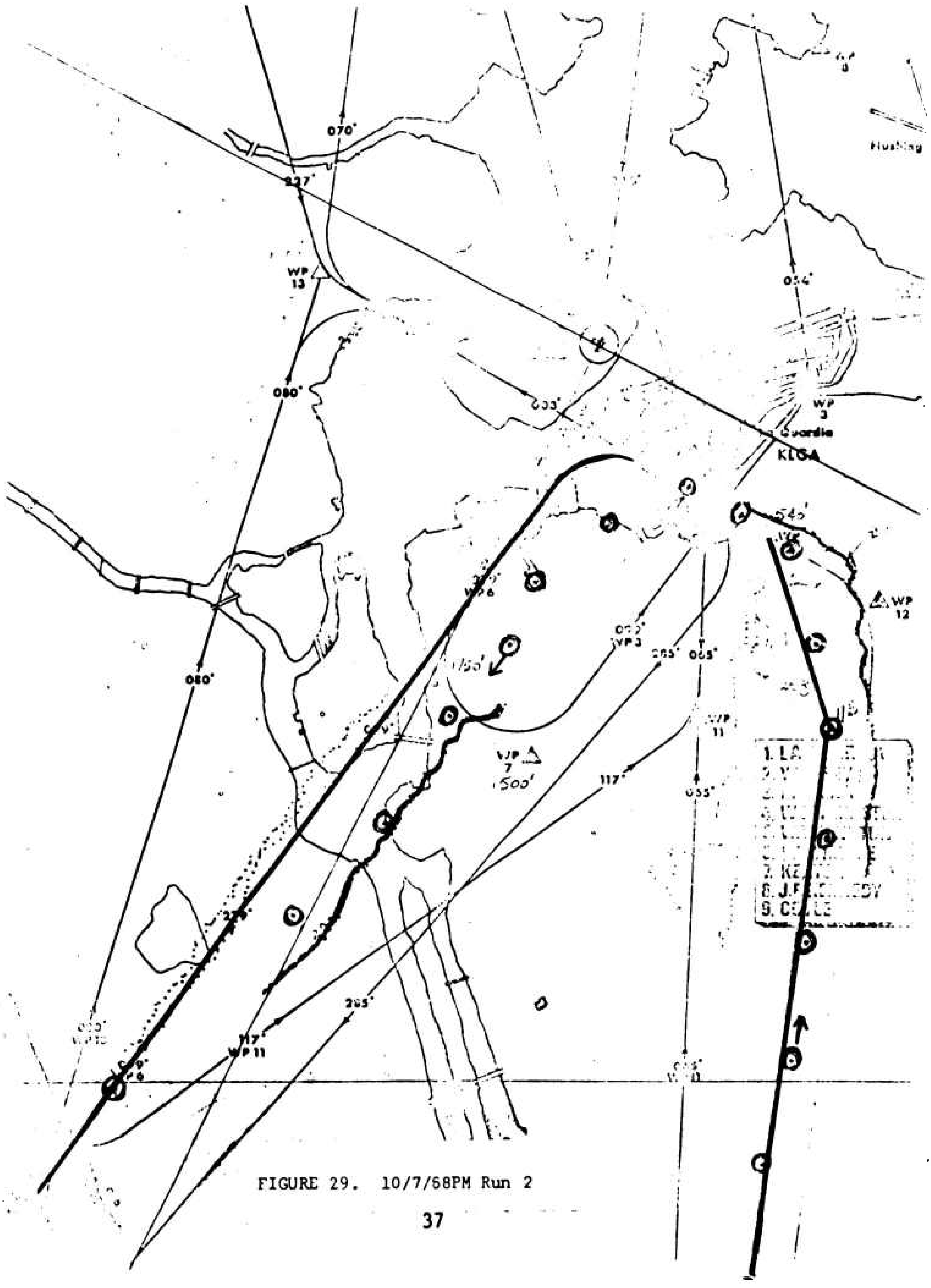


FIGURE 29. 10/7/68PM Run 2

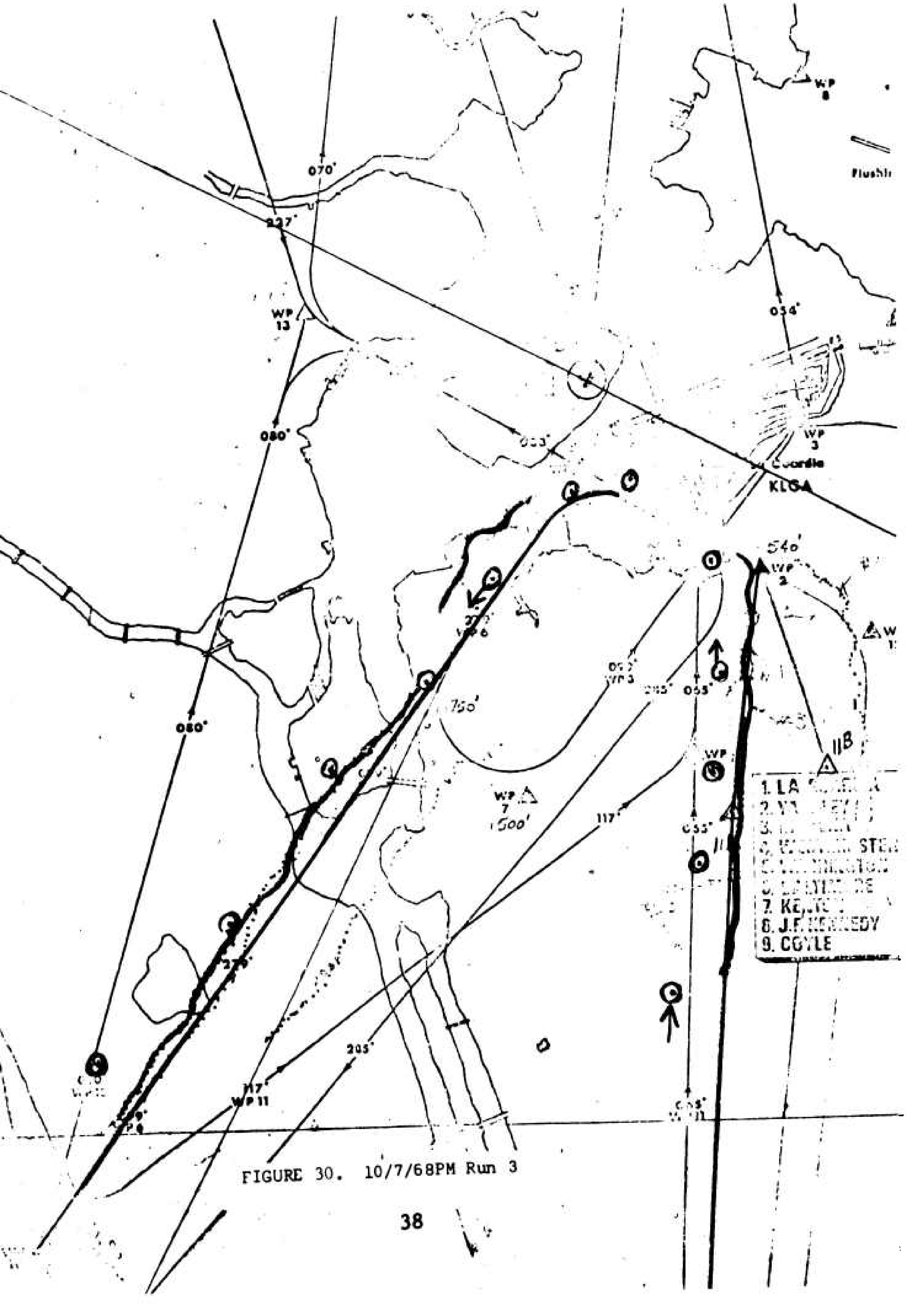


FIGURE 30. 10/7/68PM Run 3

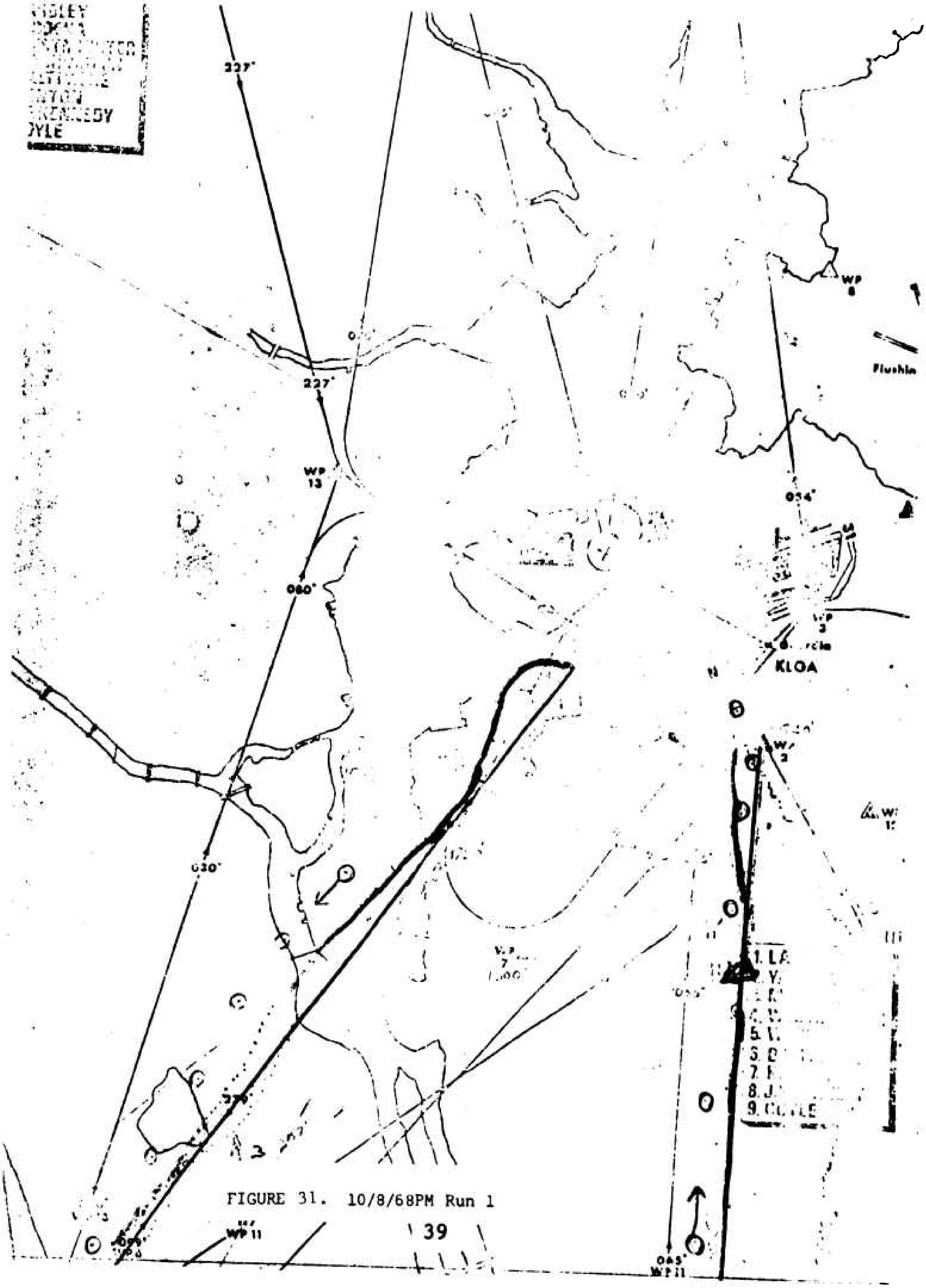


FIGURE 31. 10/8/68PM Run 1

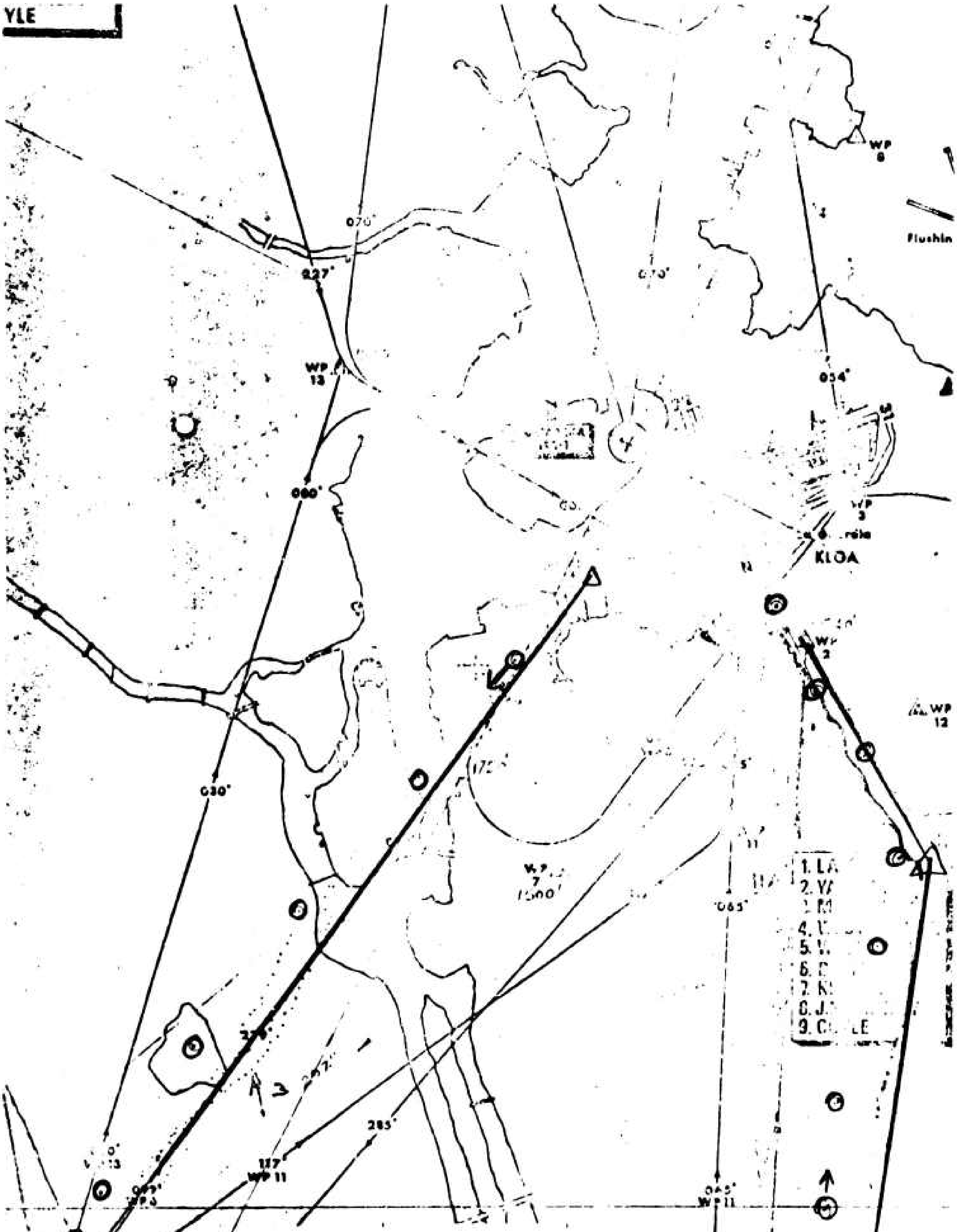


FIGURE 32. 10/8/68PM Run 2

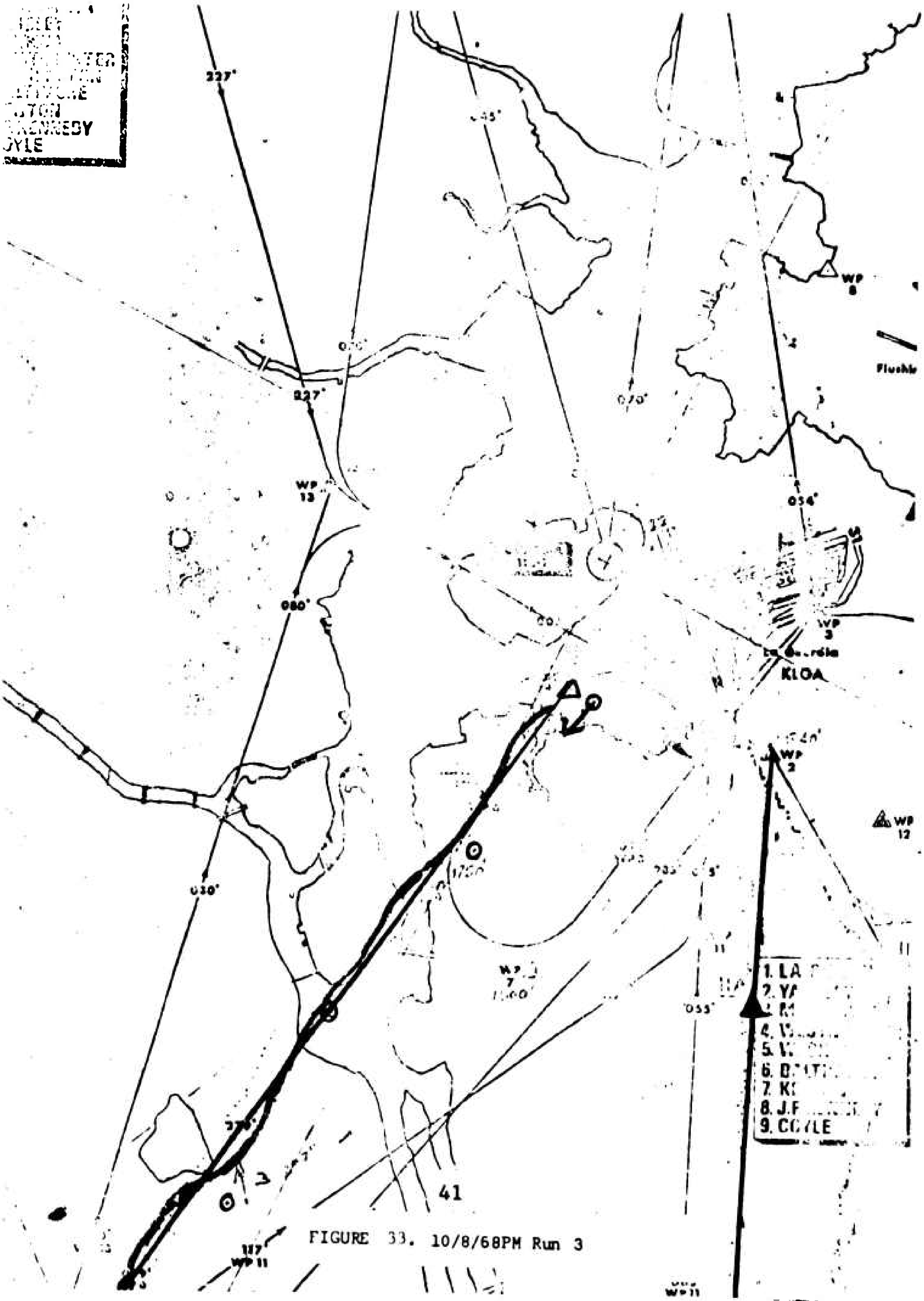


FIGURE 33. 10/8/68PM Run 3

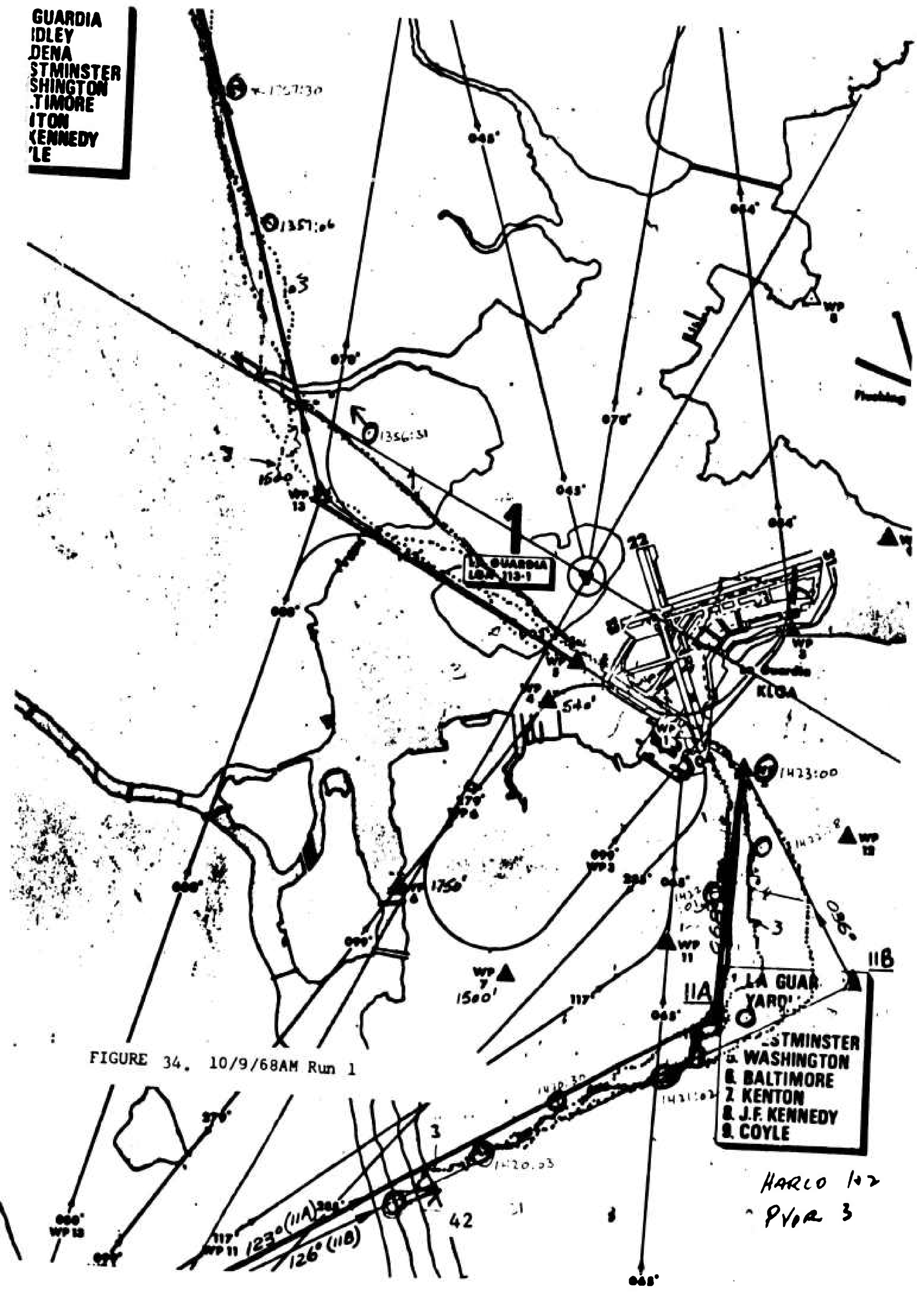


FIGURE 34. 10/9/68AM Run 1

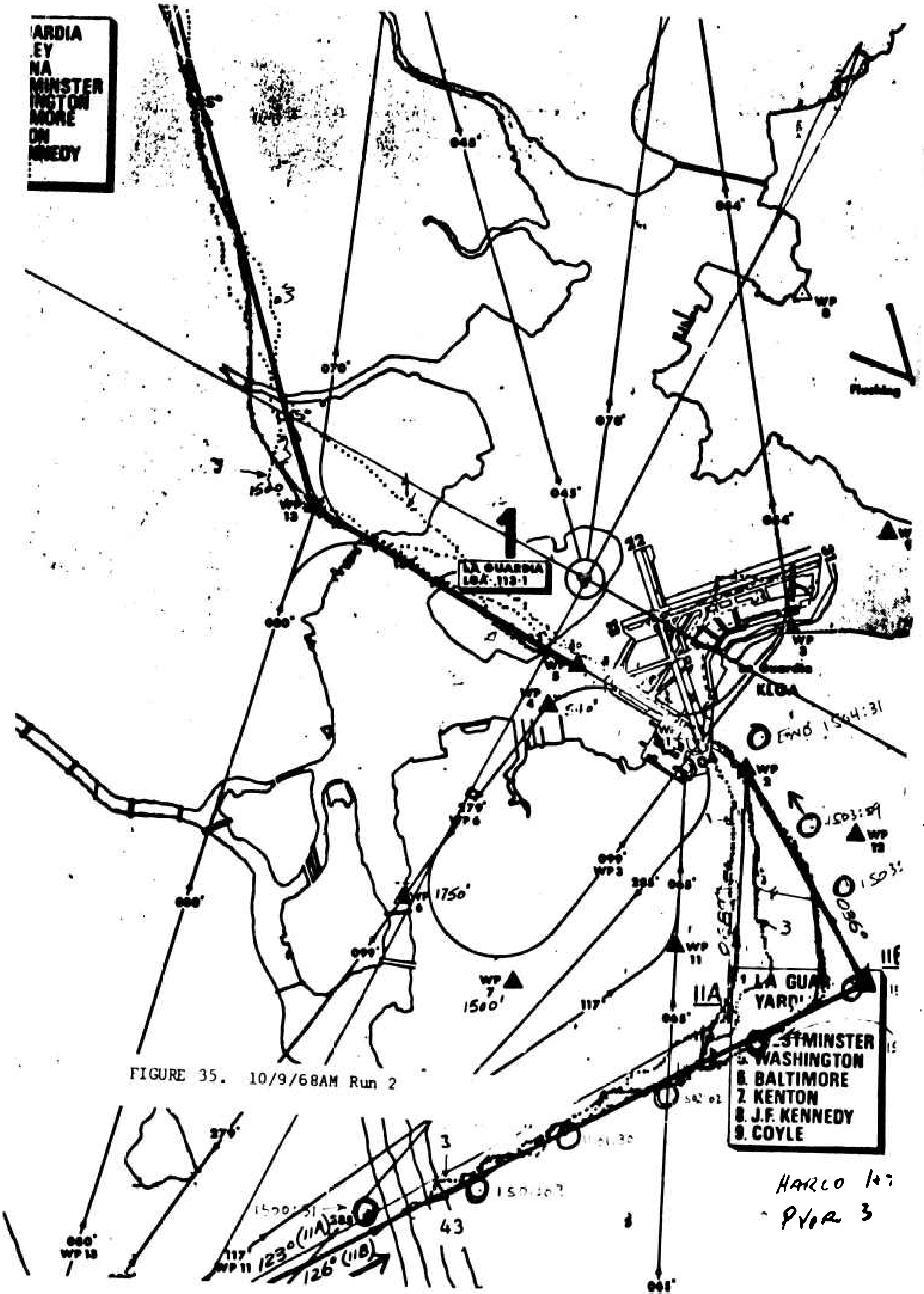


FIGURE 35. 10/9/68AM Run 2

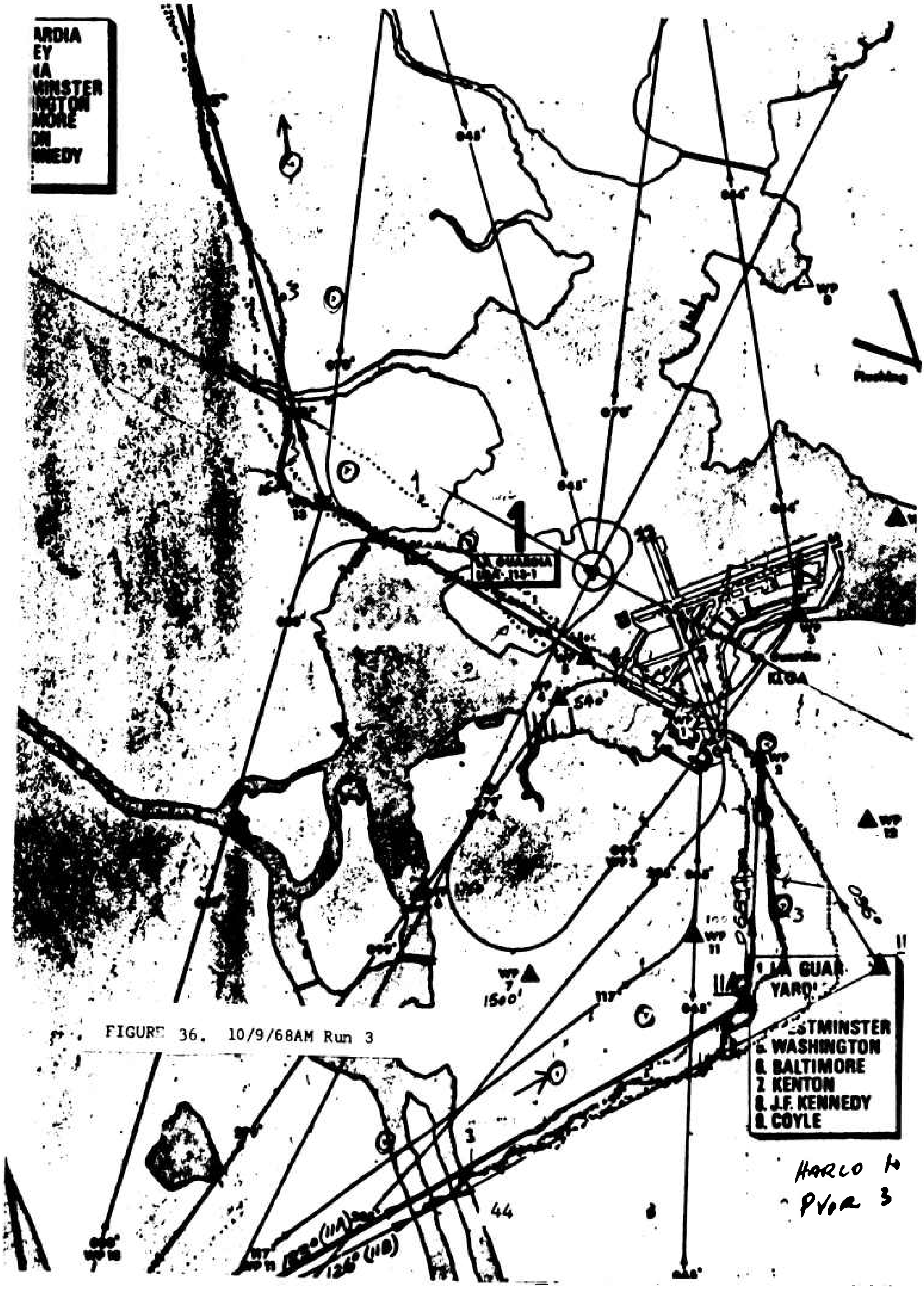


FIGURE 36. 10/9/68AM Run 3

HARLO 10
PVOR 3

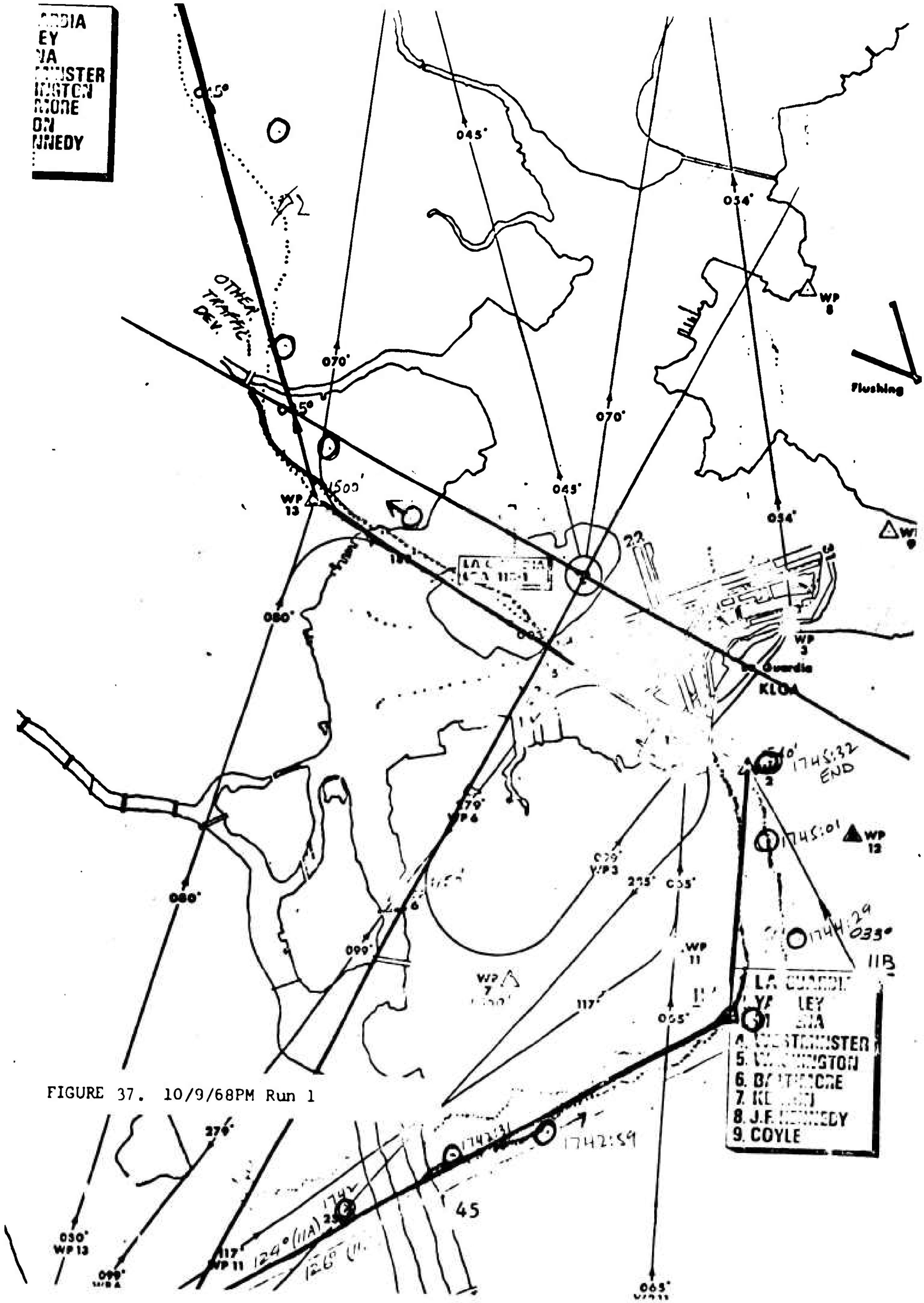


FIGURE 37. 10/9/68PM Run 1

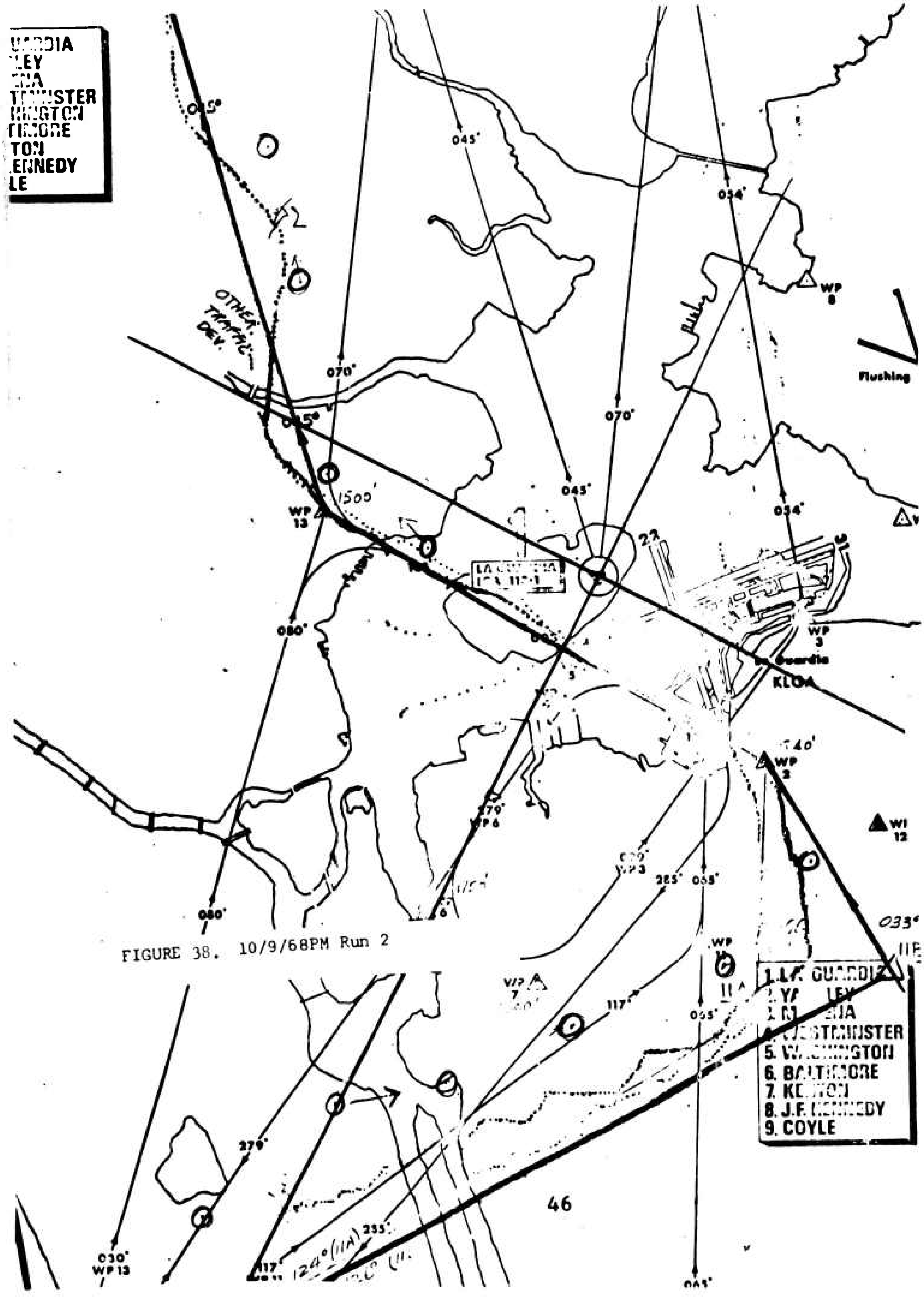


FIGURE 38. 10/9/68PM Run 2

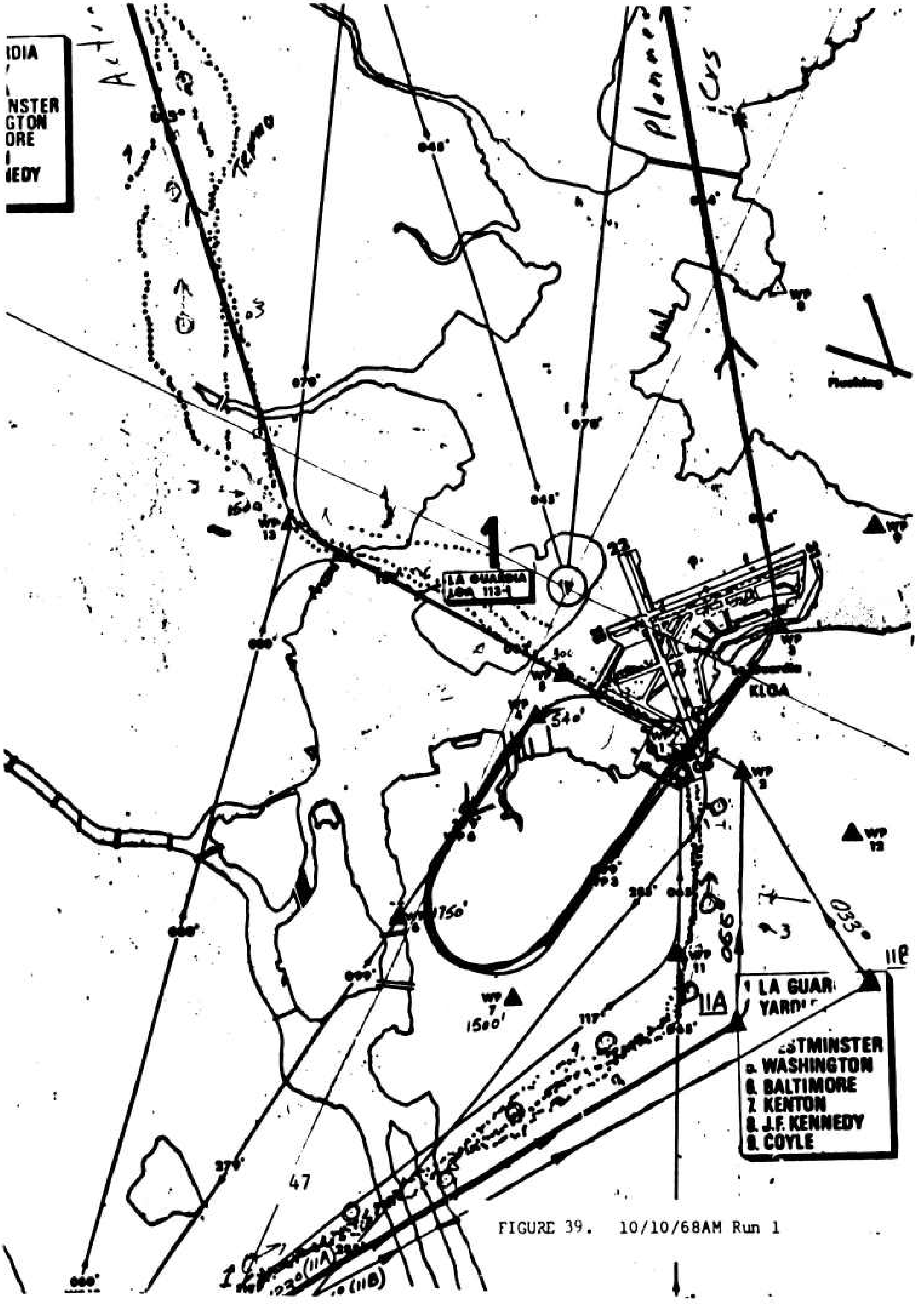


FIGURE 39. 10/10/68AM Run 1

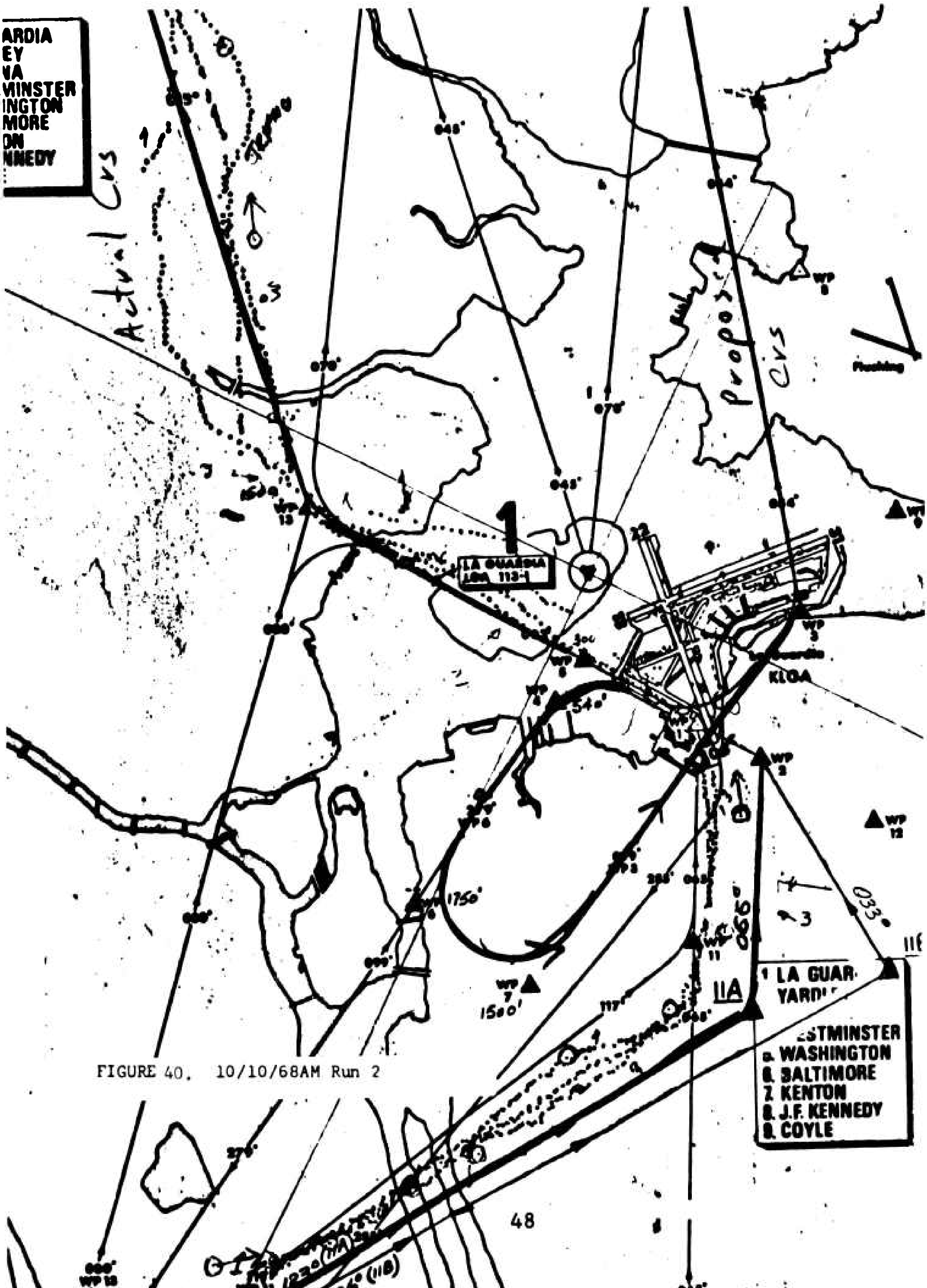


FIGURE 40. 10/10/68AM Run 2

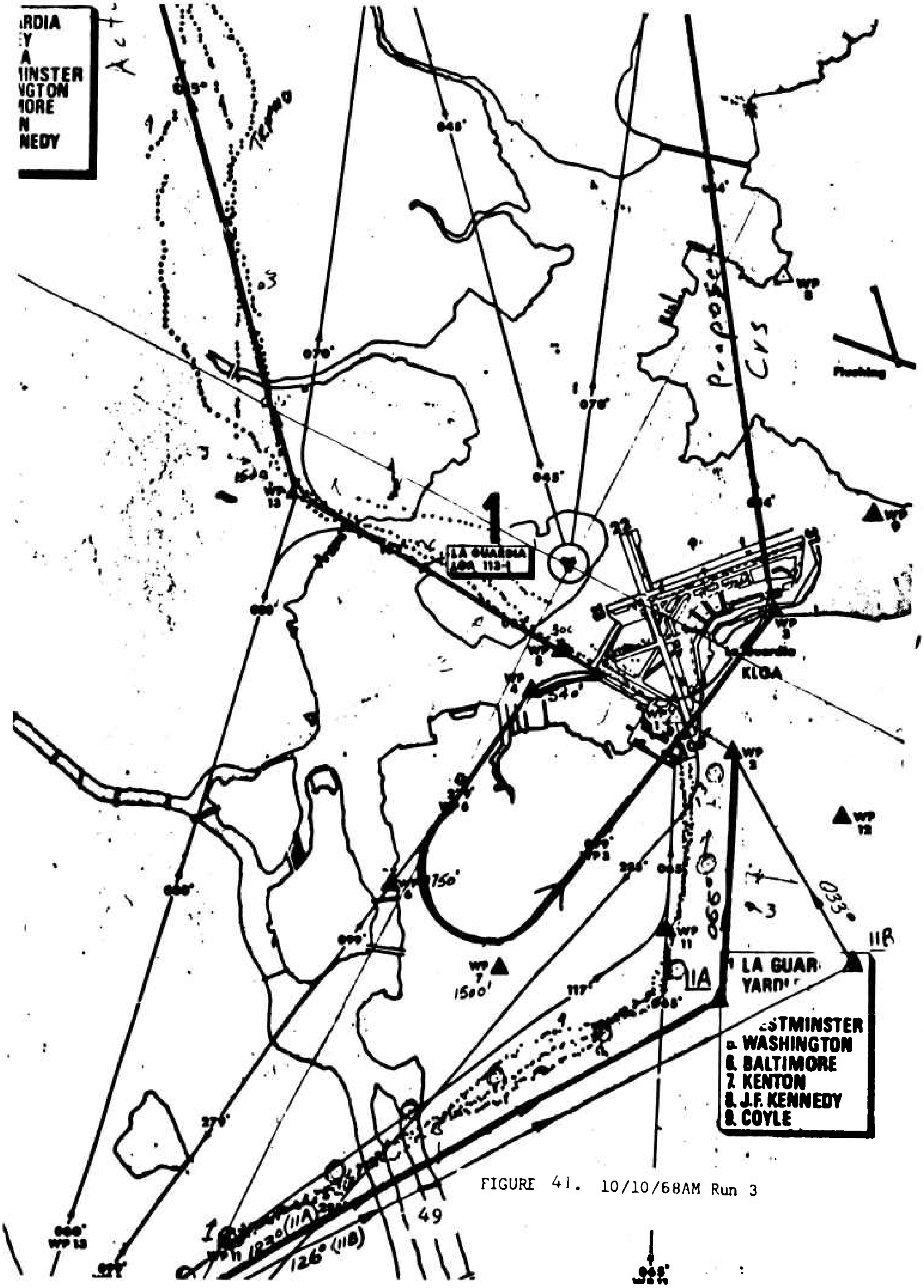


FIGURE 41. 10/10/68AM Run 3

49

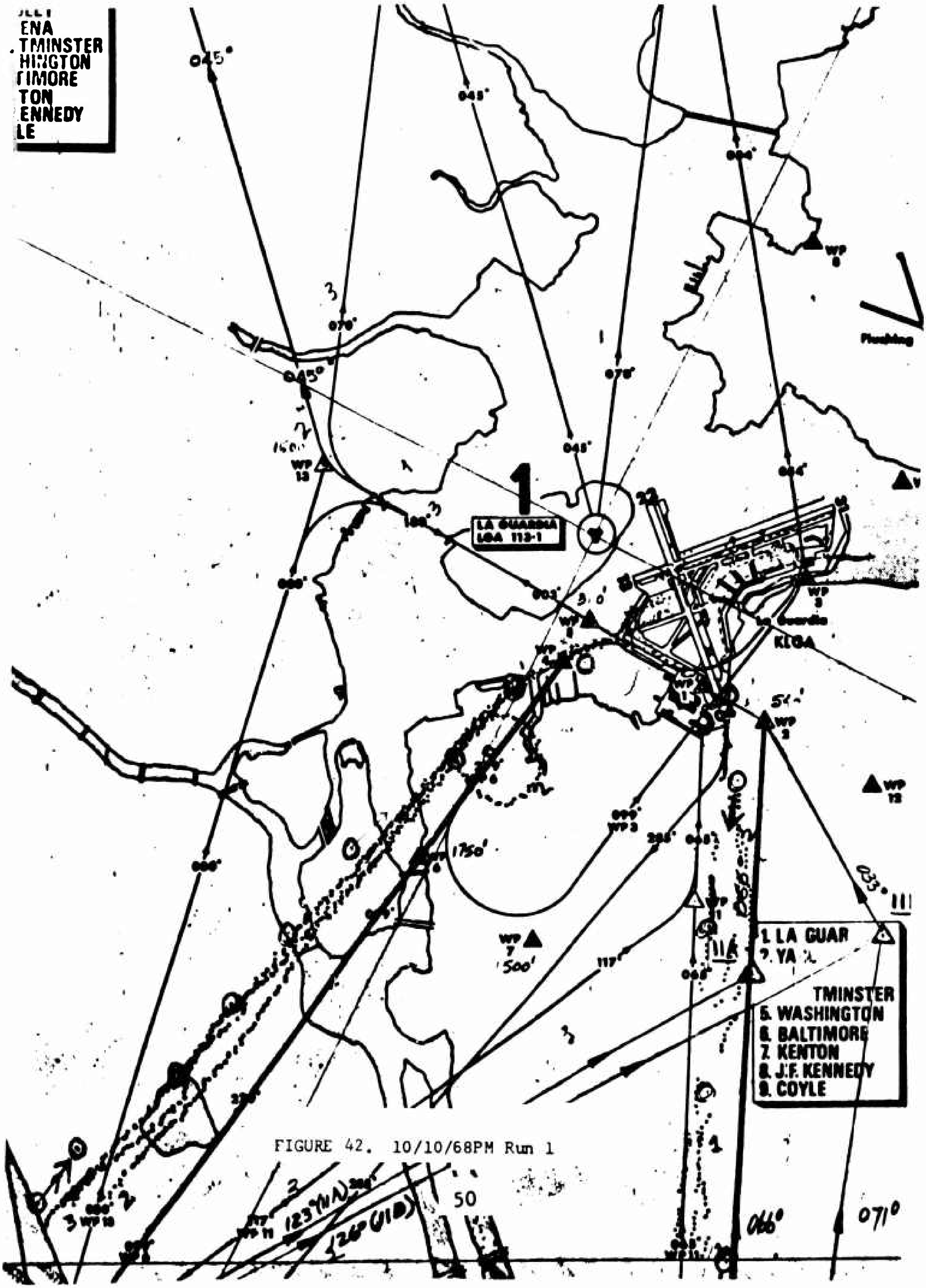


FIGURE 42. 10/10/68PM Run 1

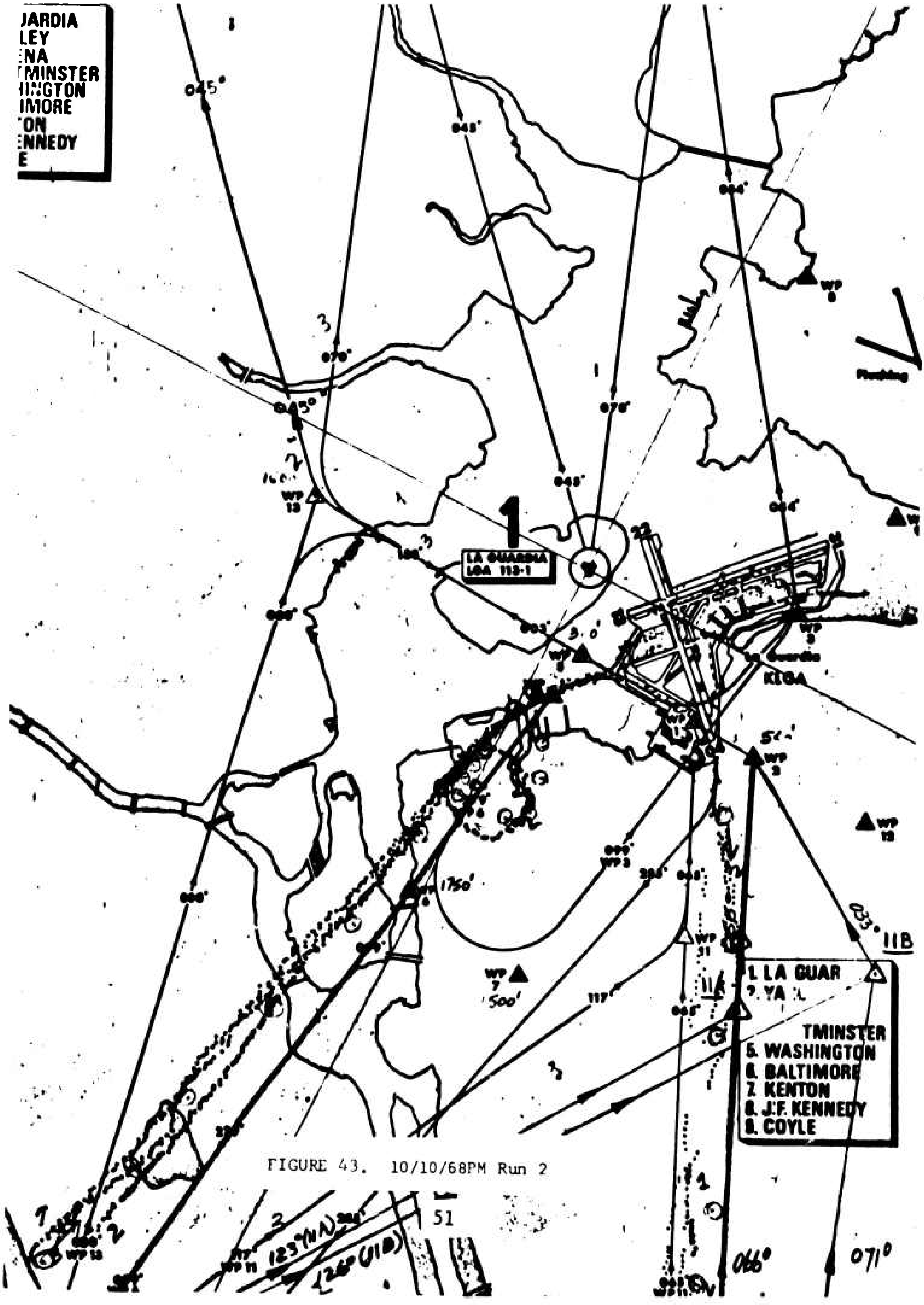


FIGURE 43. 10/10/68PM Run 2

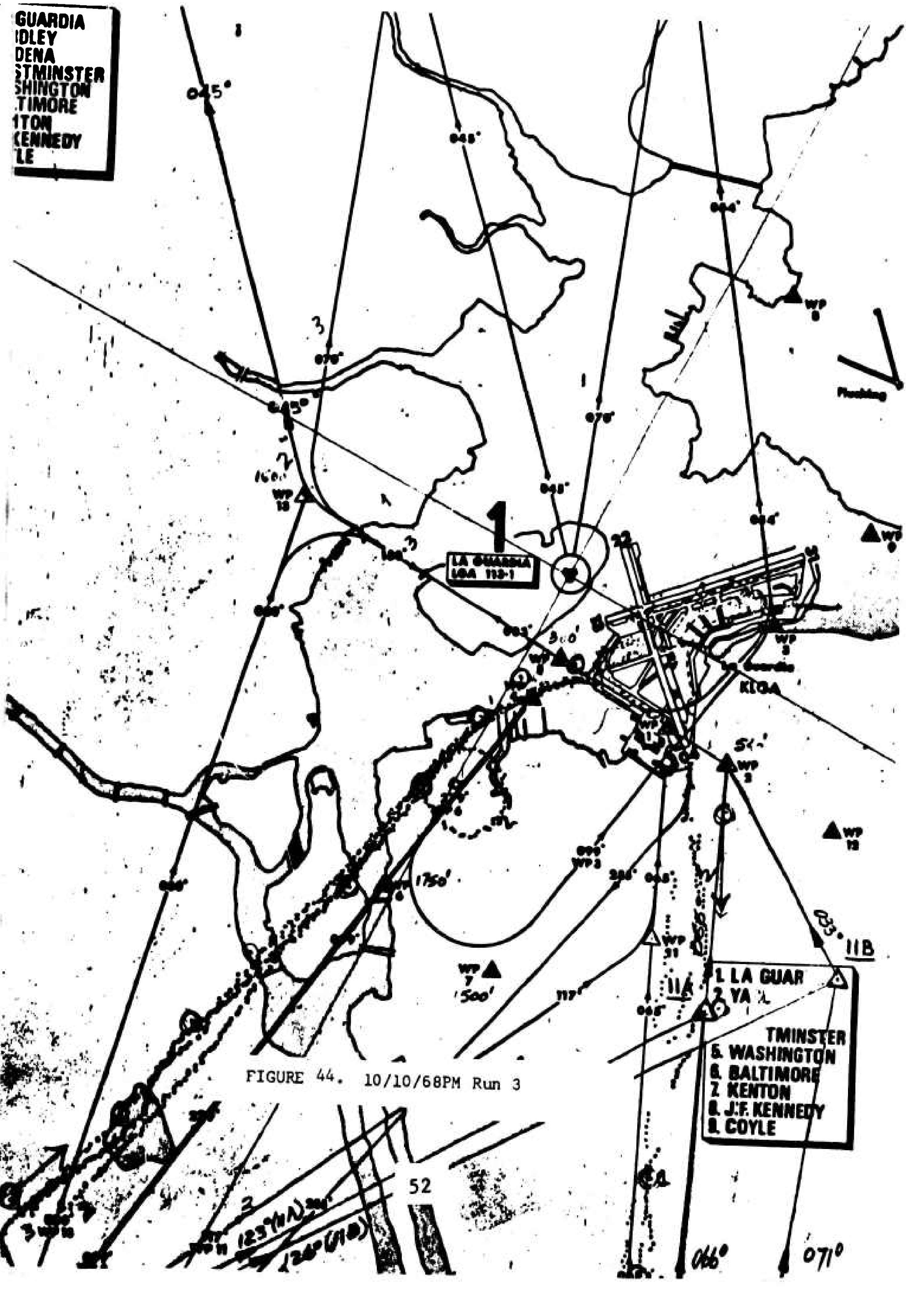


FIGURE 44. 10/10/68PM Run 3

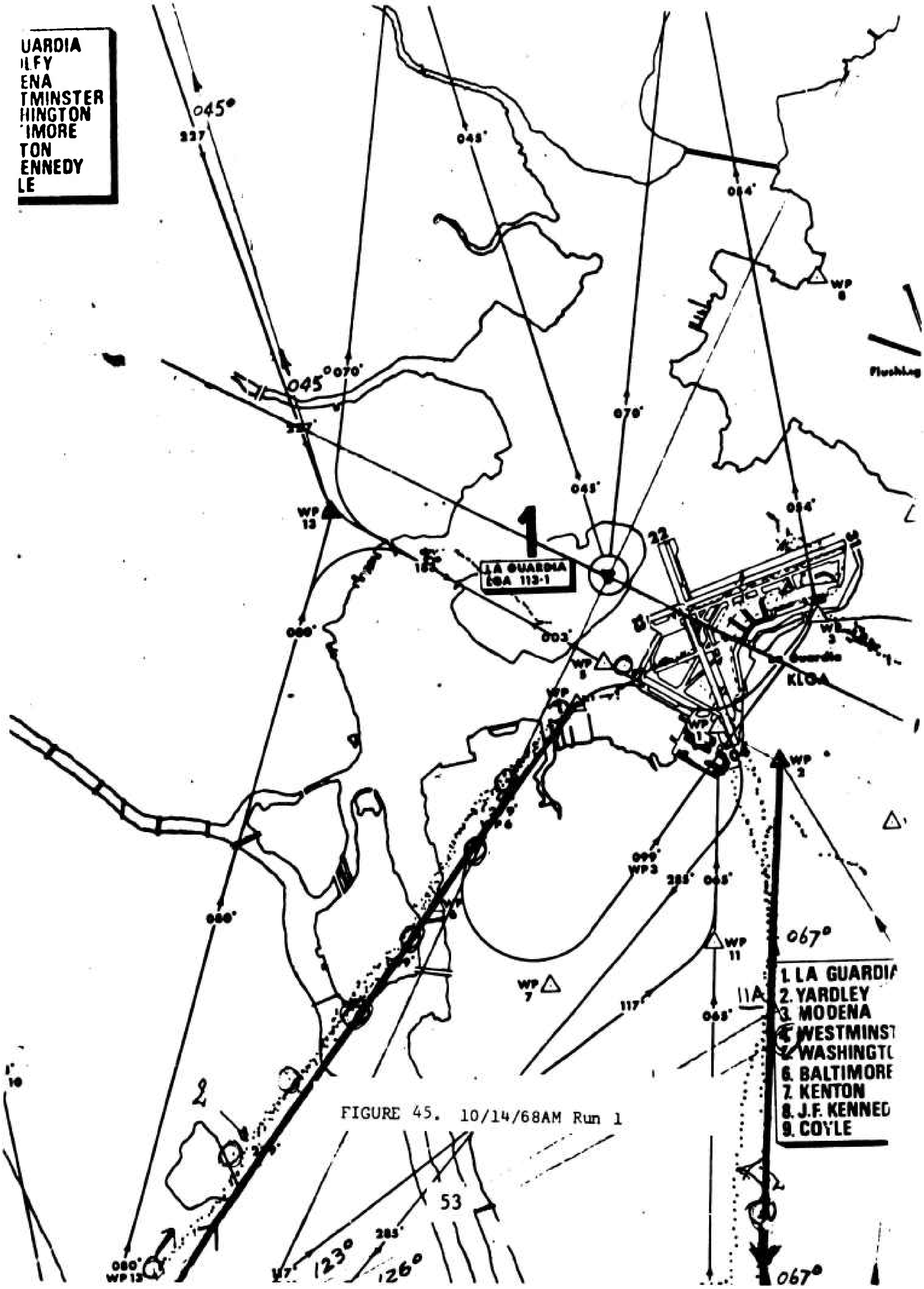


FIGURE 45. 10/14/68AM Run 1

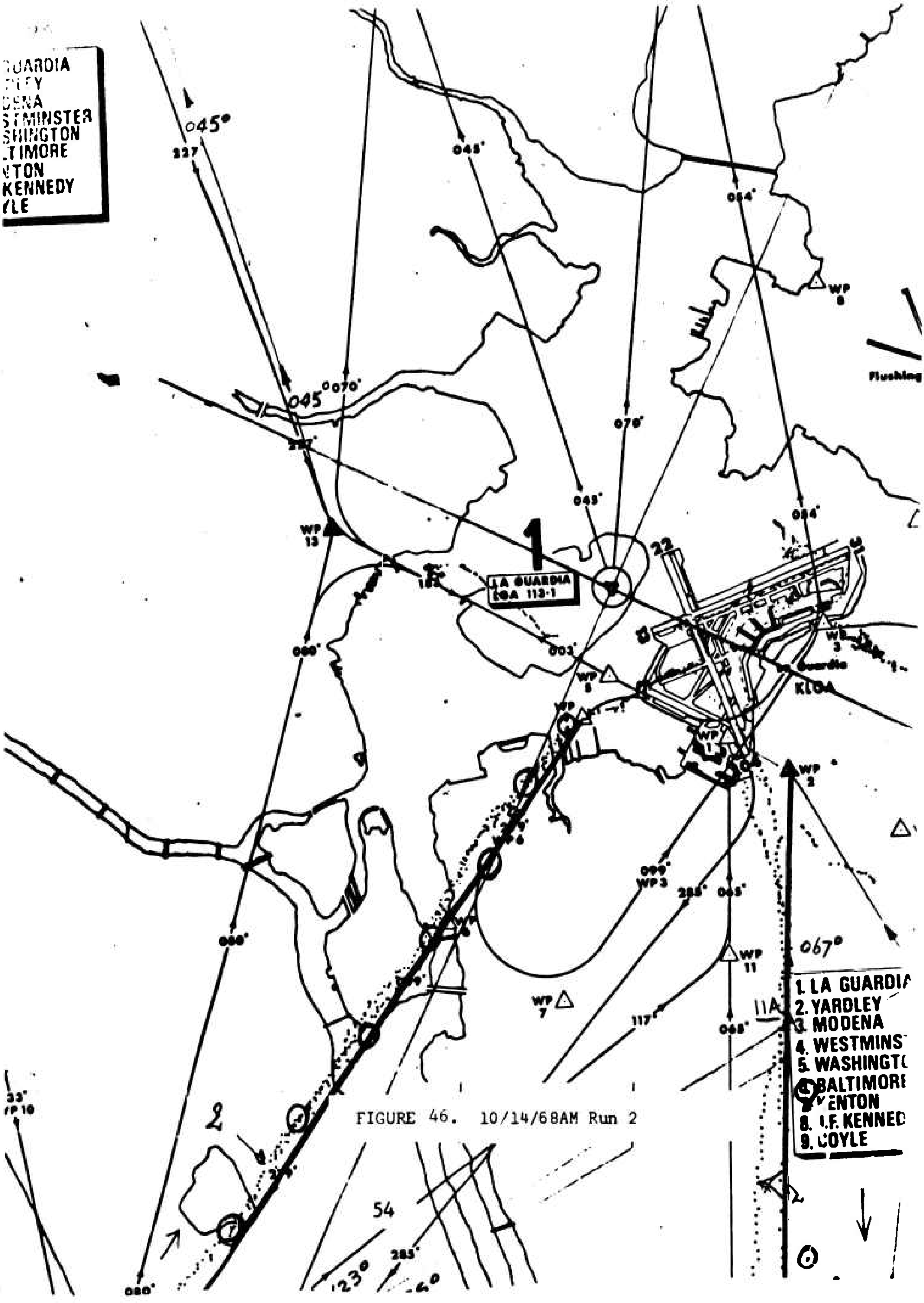


FIGURE 46. 10/14/68AM Run 2

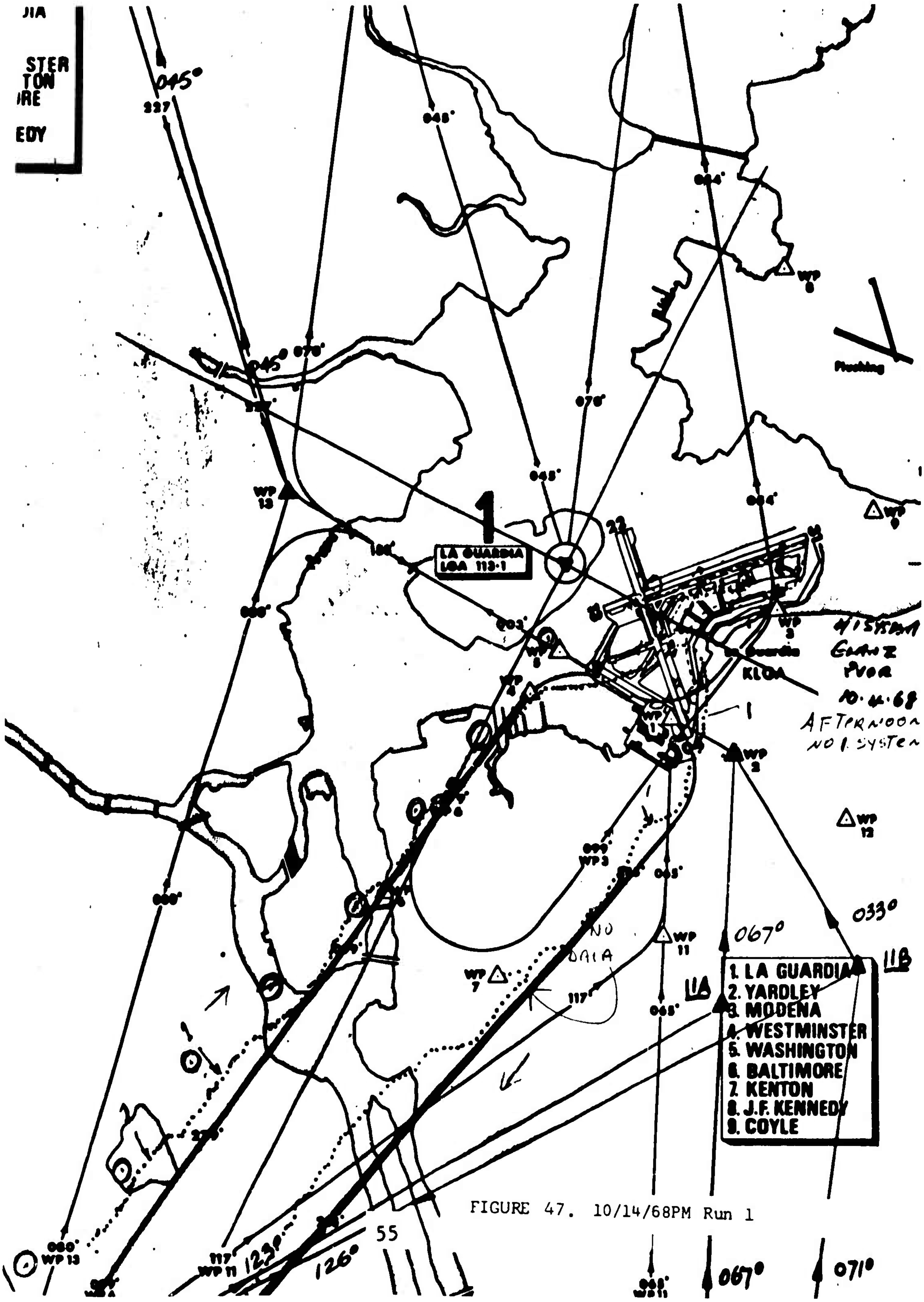


FIGURE 47. 10/14/68PM Run 1

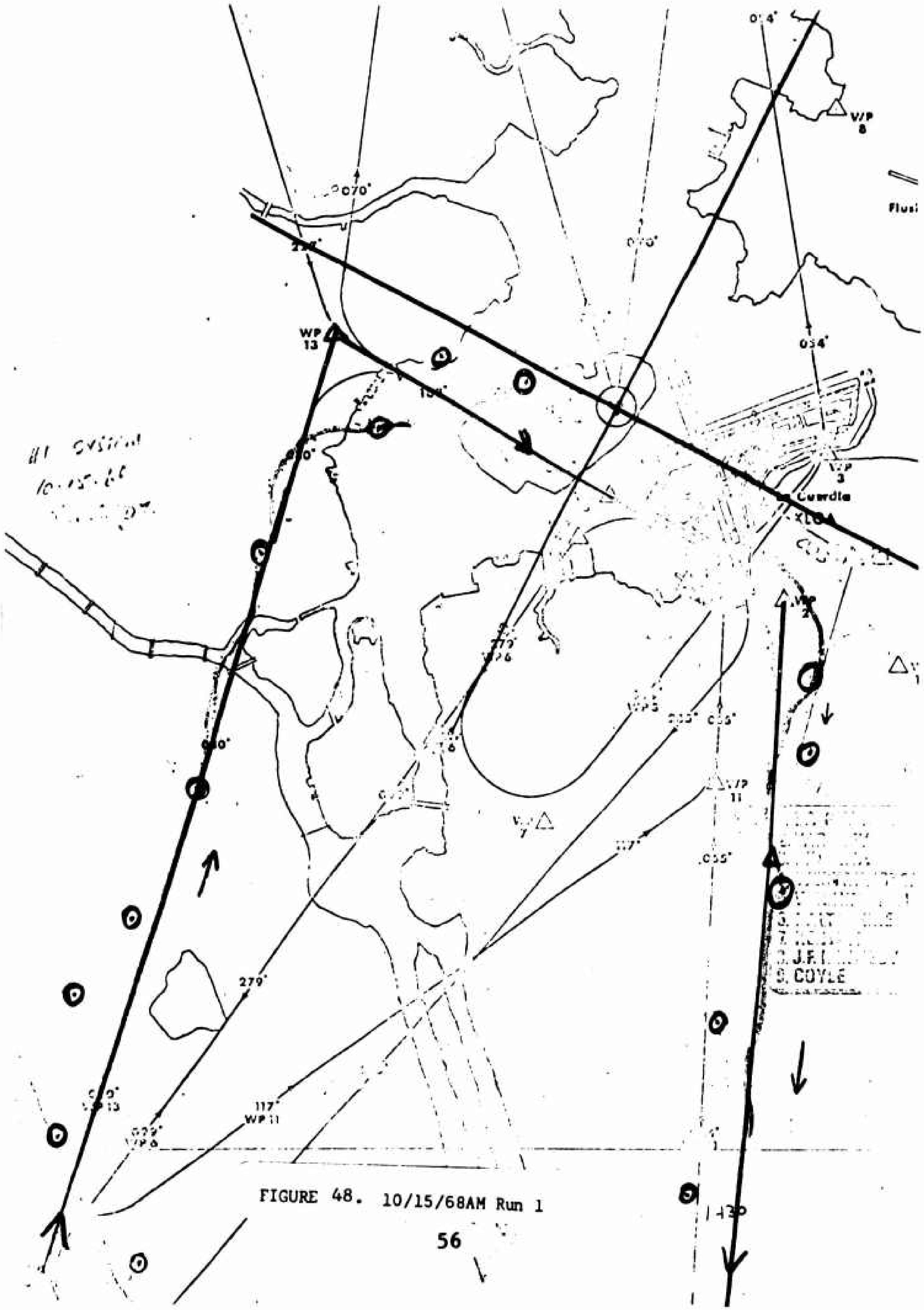


FIGURE 48. 10/15/68AM Run 1

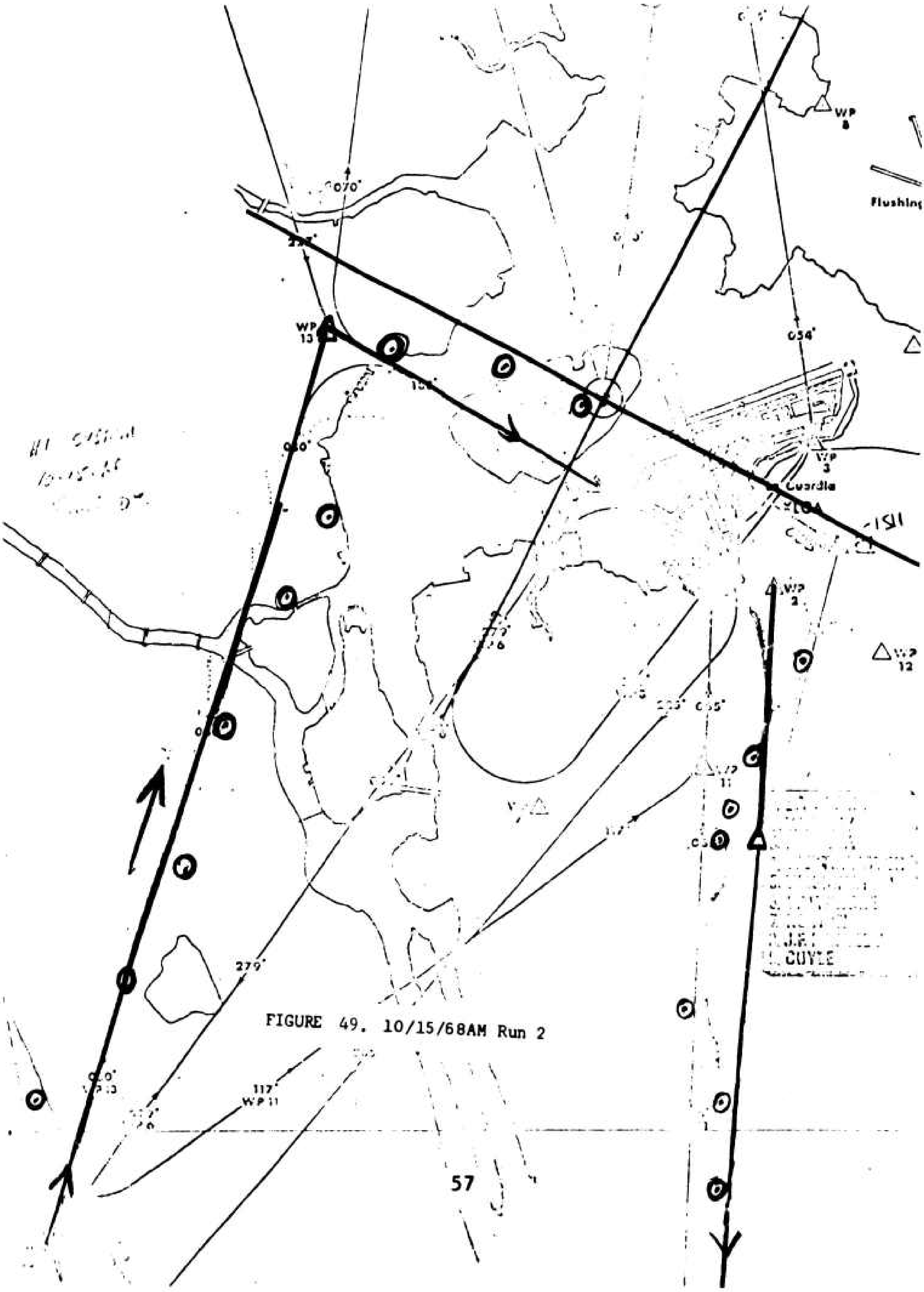


FIGURE 49. 10/15/68AM Run 2

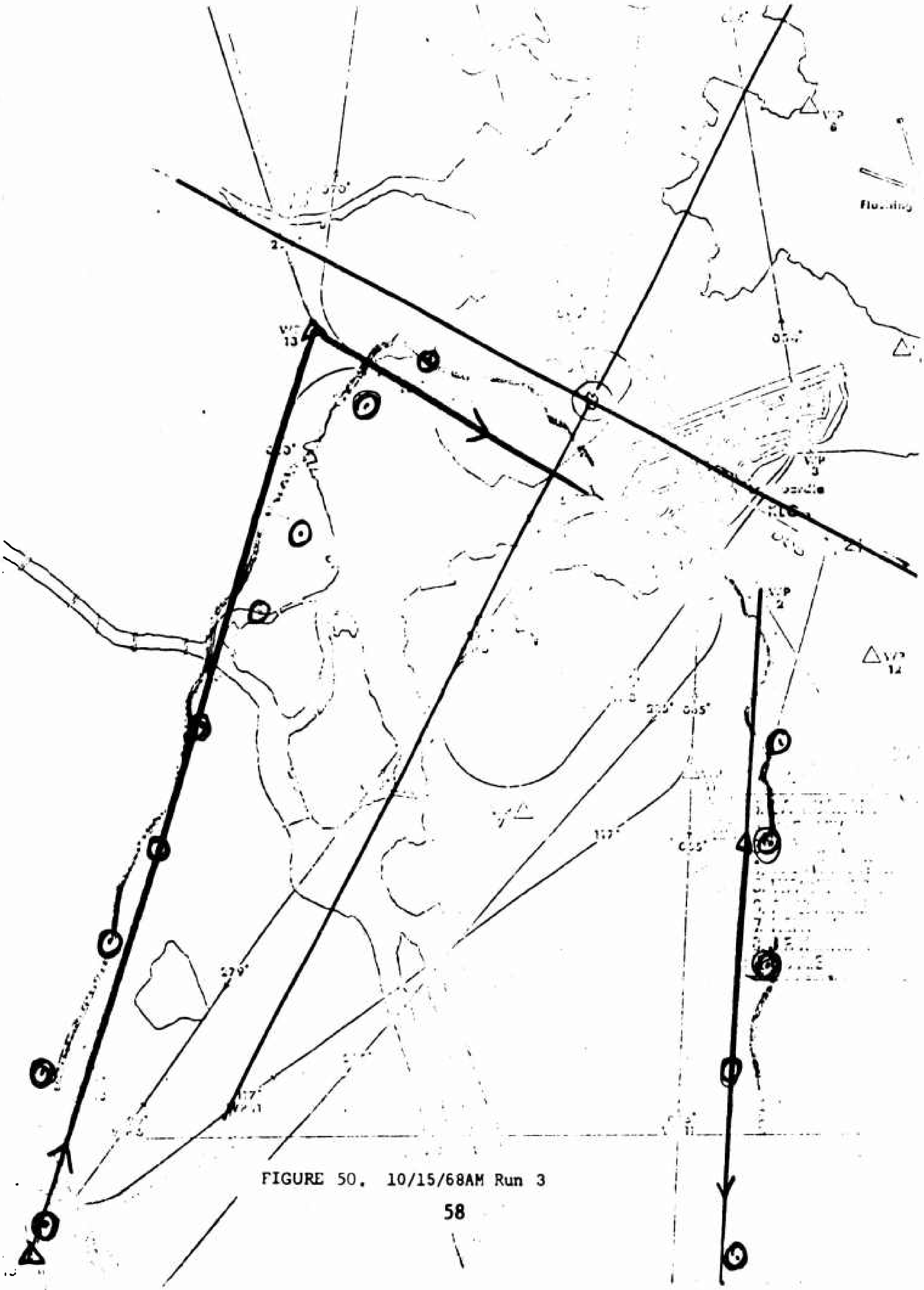


FIGURE 50. 10/15/68AM Run 3

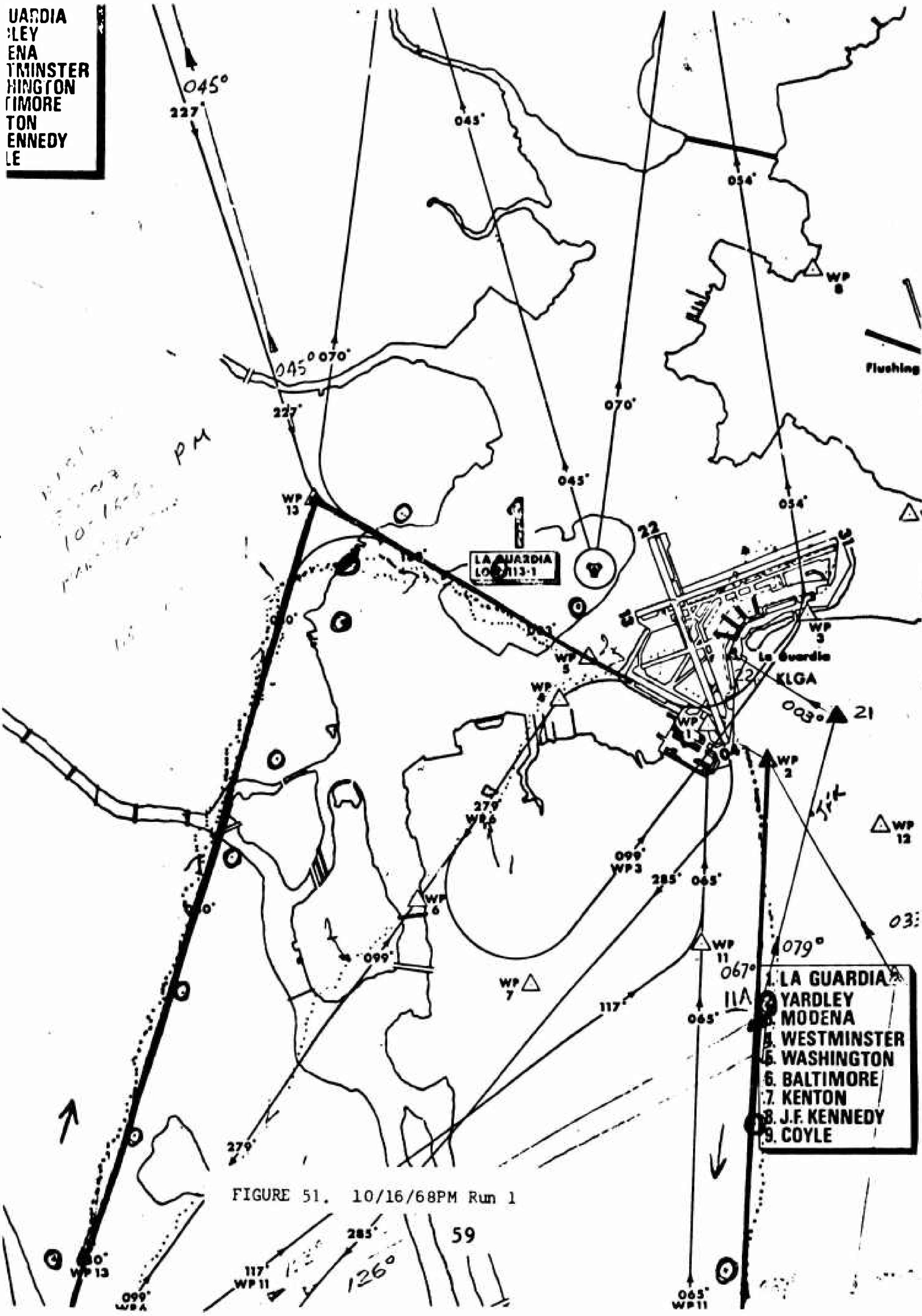


FIGURE 51. 10/16/68PM Run 1

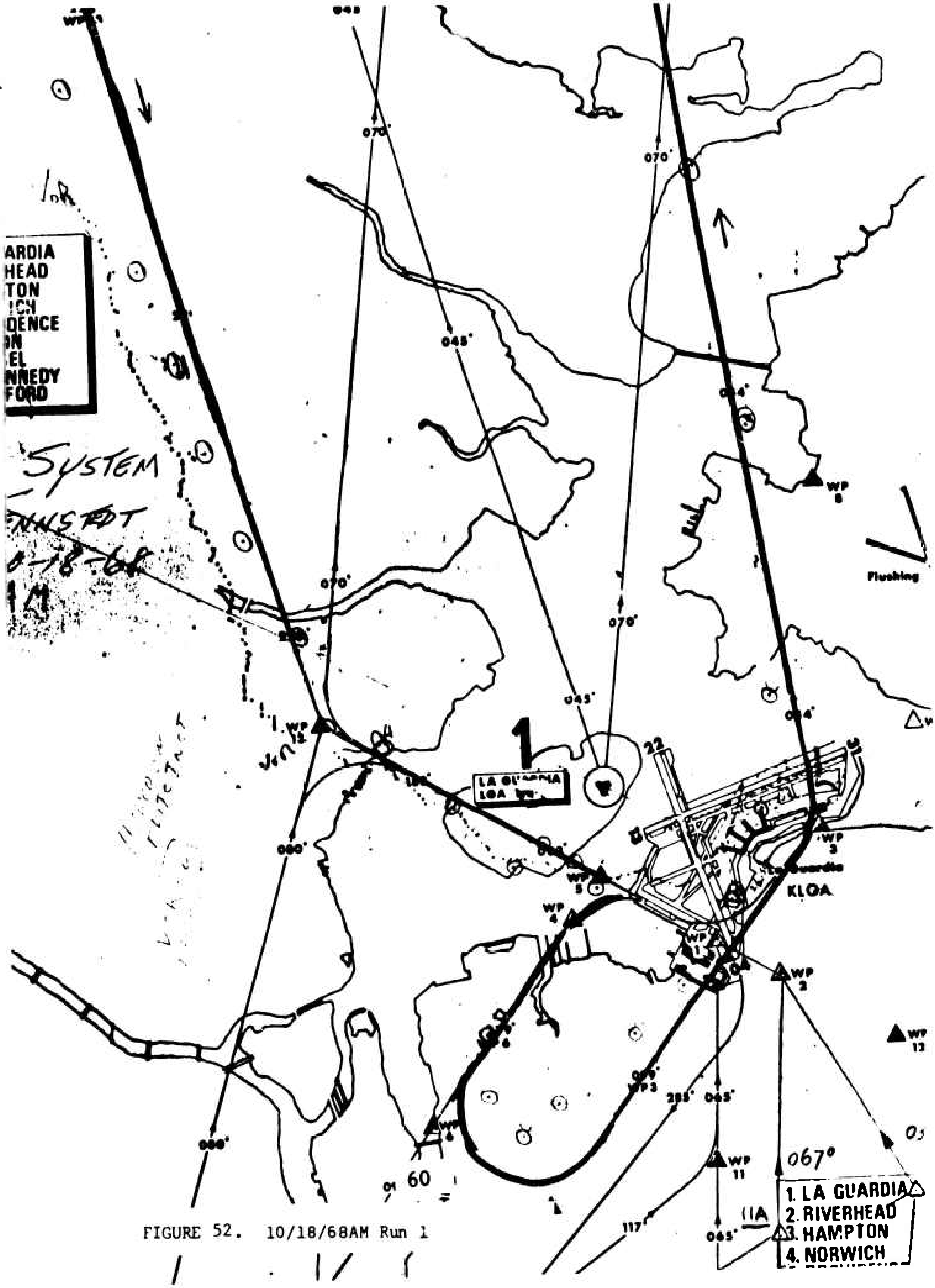


FIGURE 52. 10/18/68AM Run 1

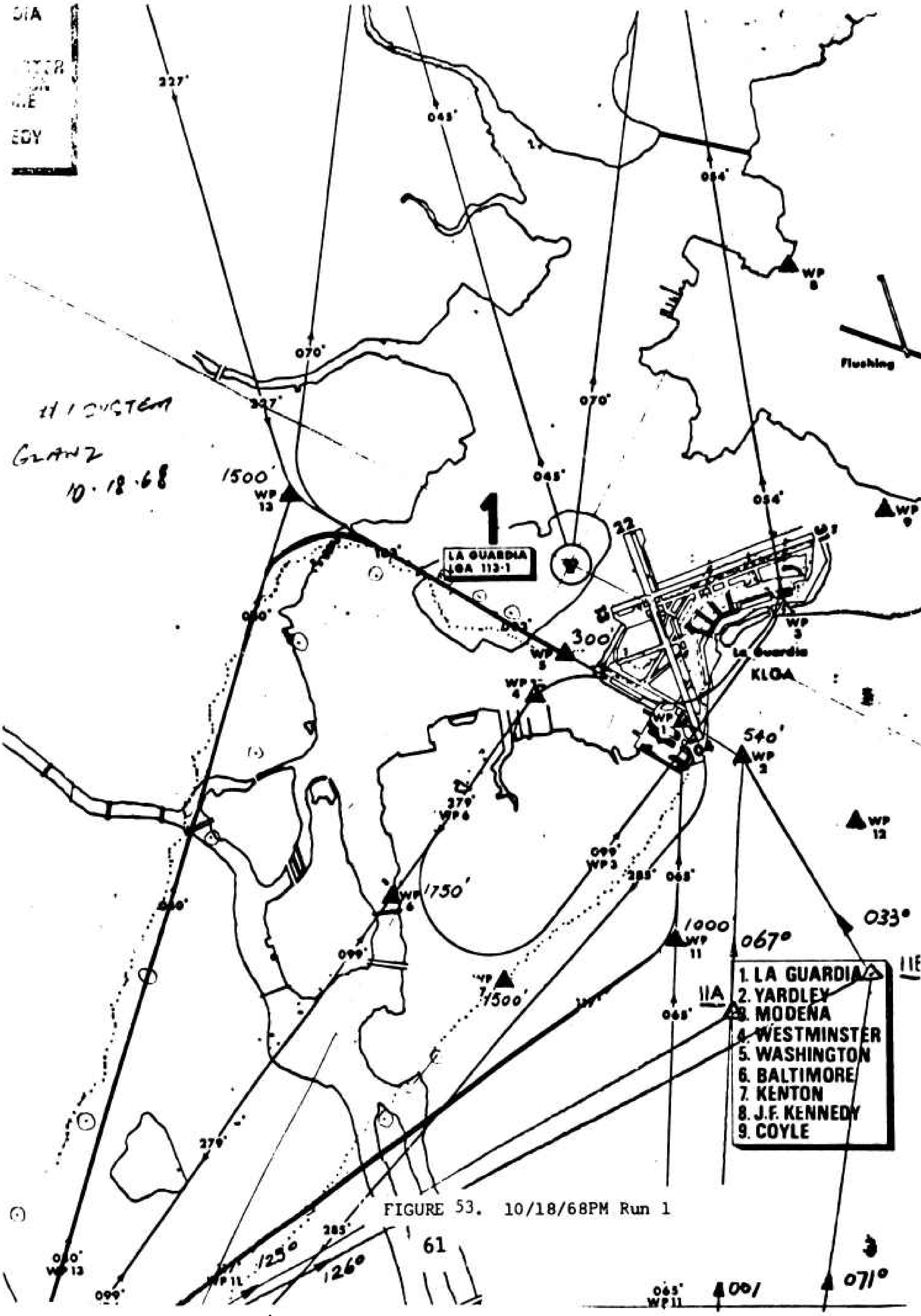


FIGURE 53. 10/18/68PM Run 1

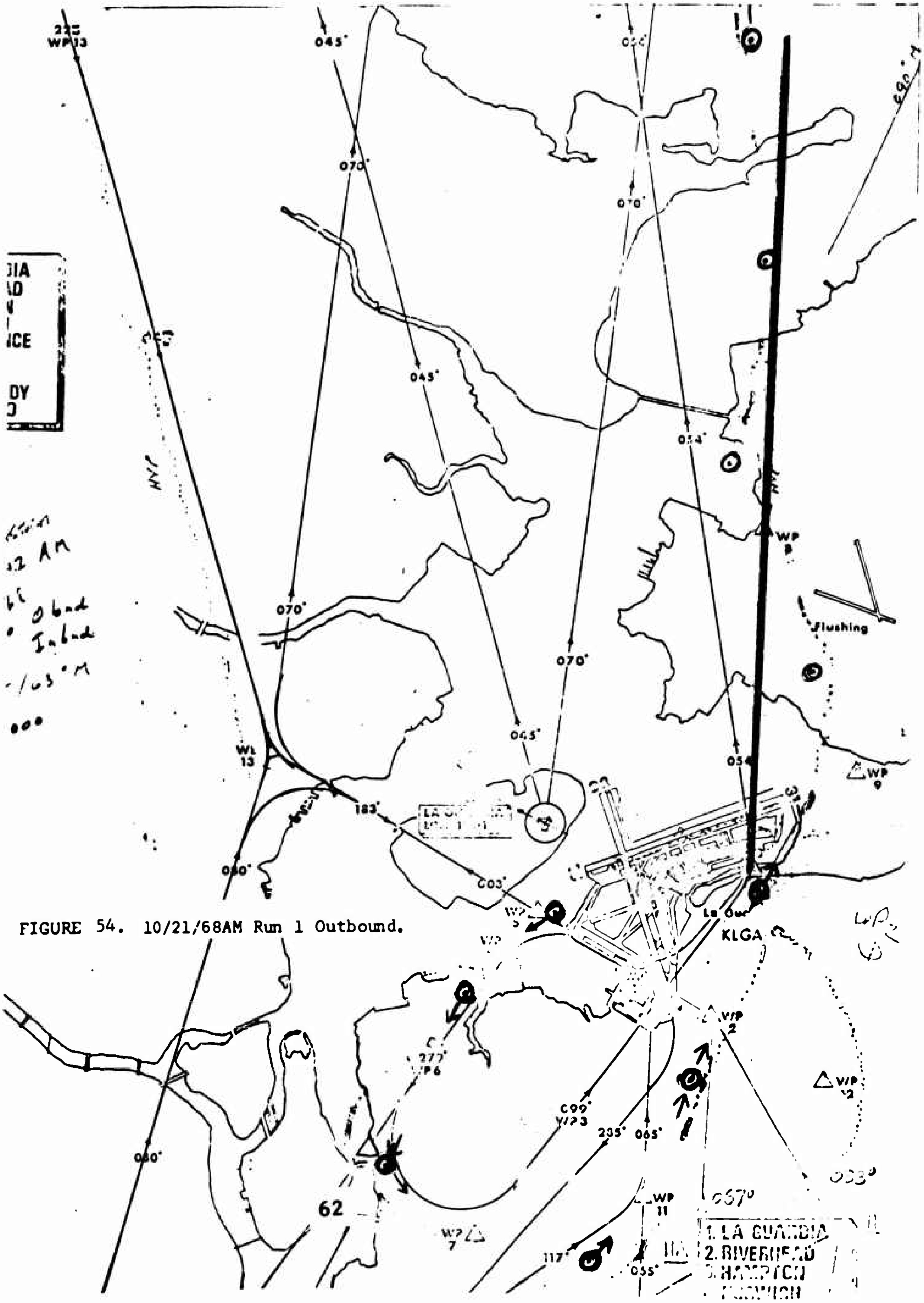


FIGURE 54. 10/21/68AM Run 1 Outbound.

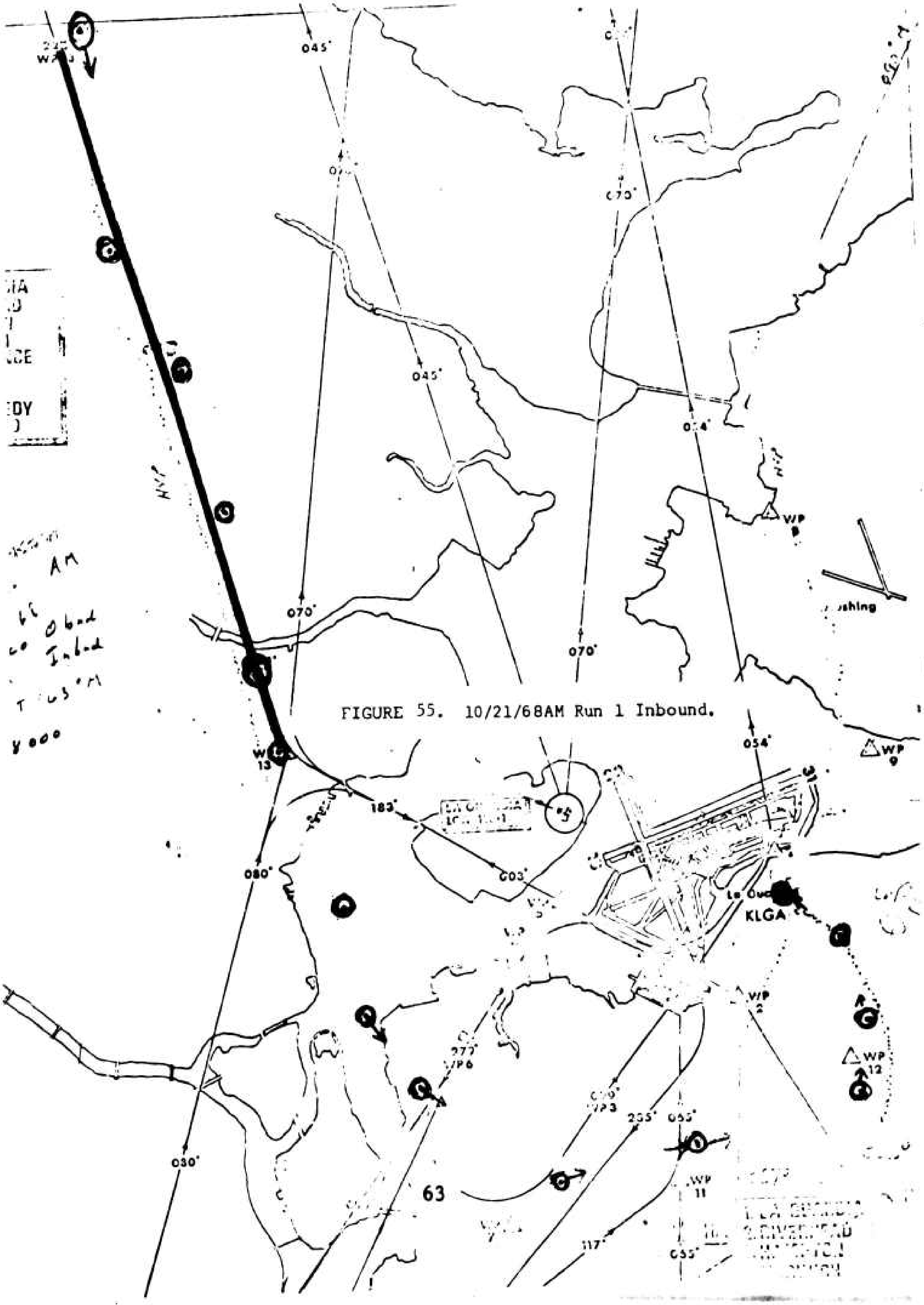


FIGURE 55. 10/21/68AM Run 1 Inbound.

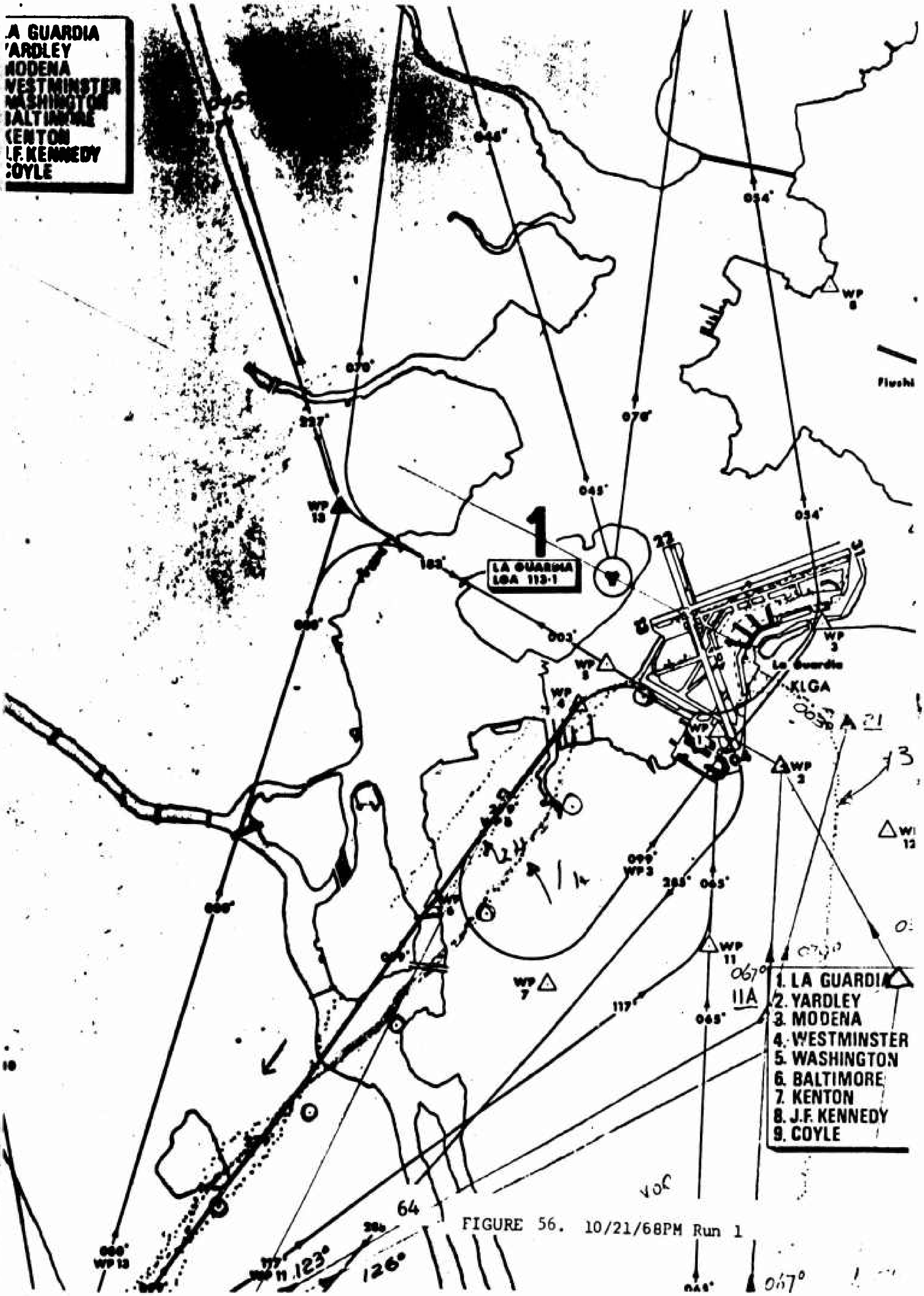
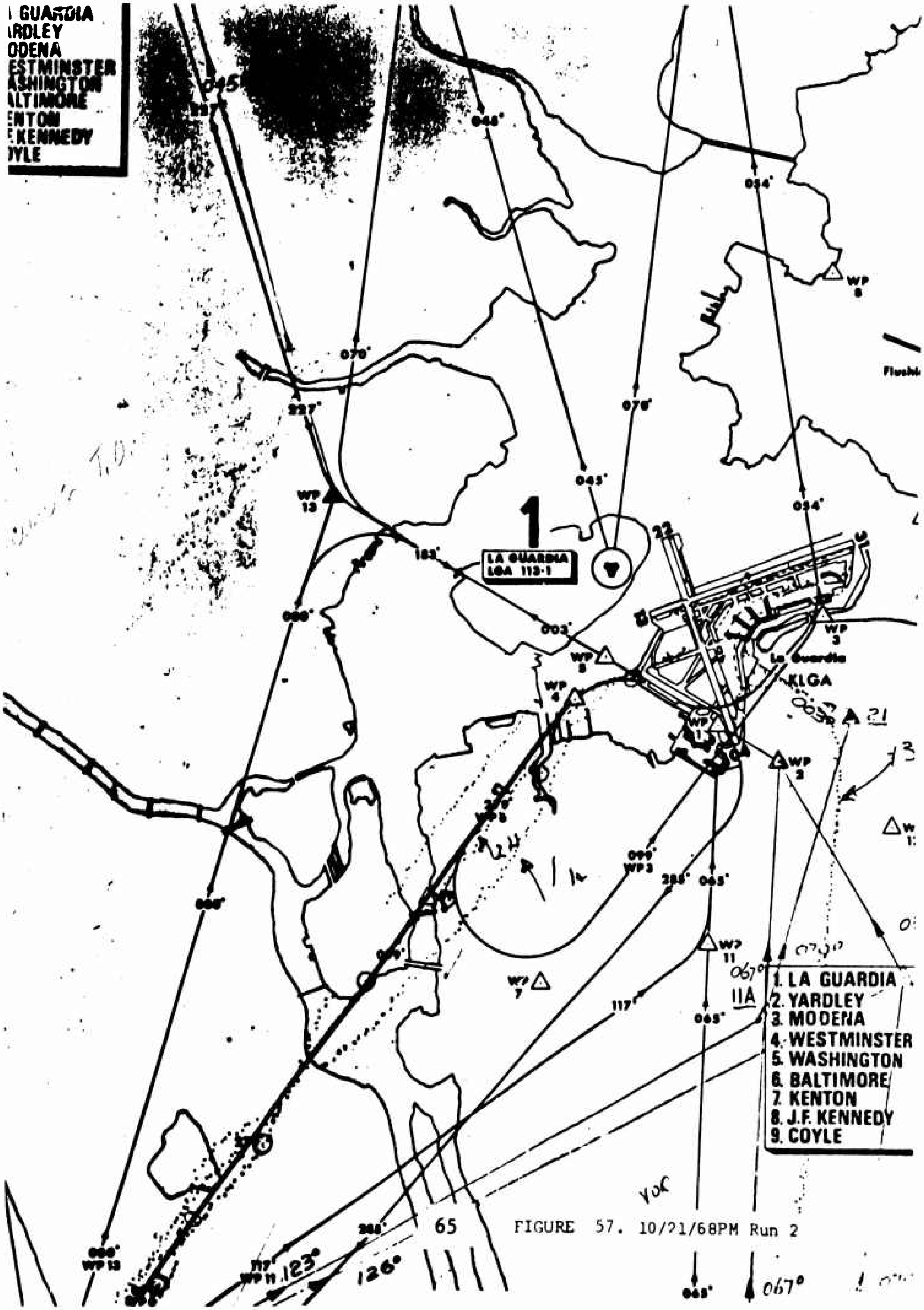


FIGURE 56. 10/21/68PM Run 1



65 FIGURE 57. 10/21/68PM Run 2

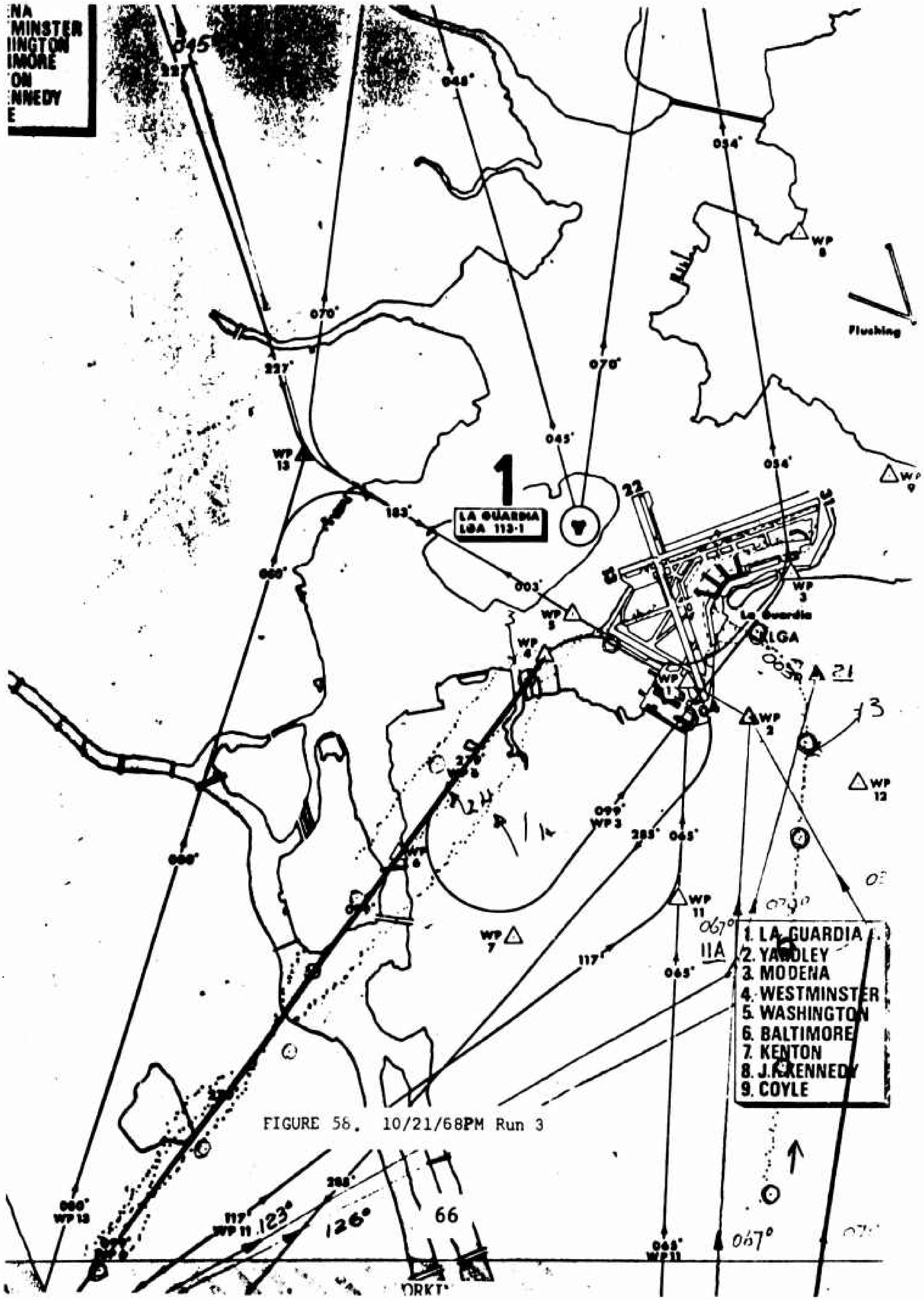


FIGURE 58. 10/21/68PM Run 3

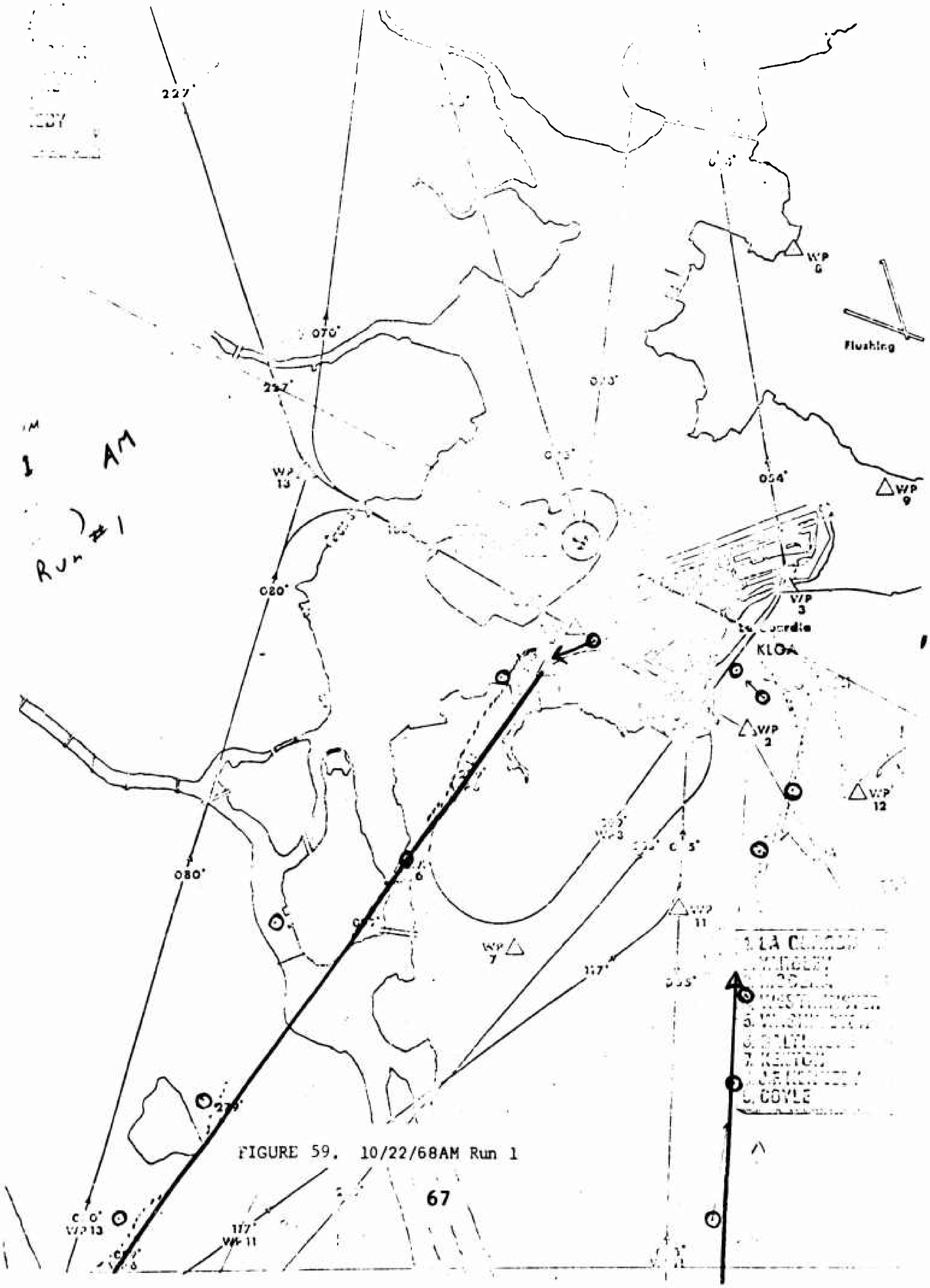


FIGURE 59. 10/22/68AM Run 1

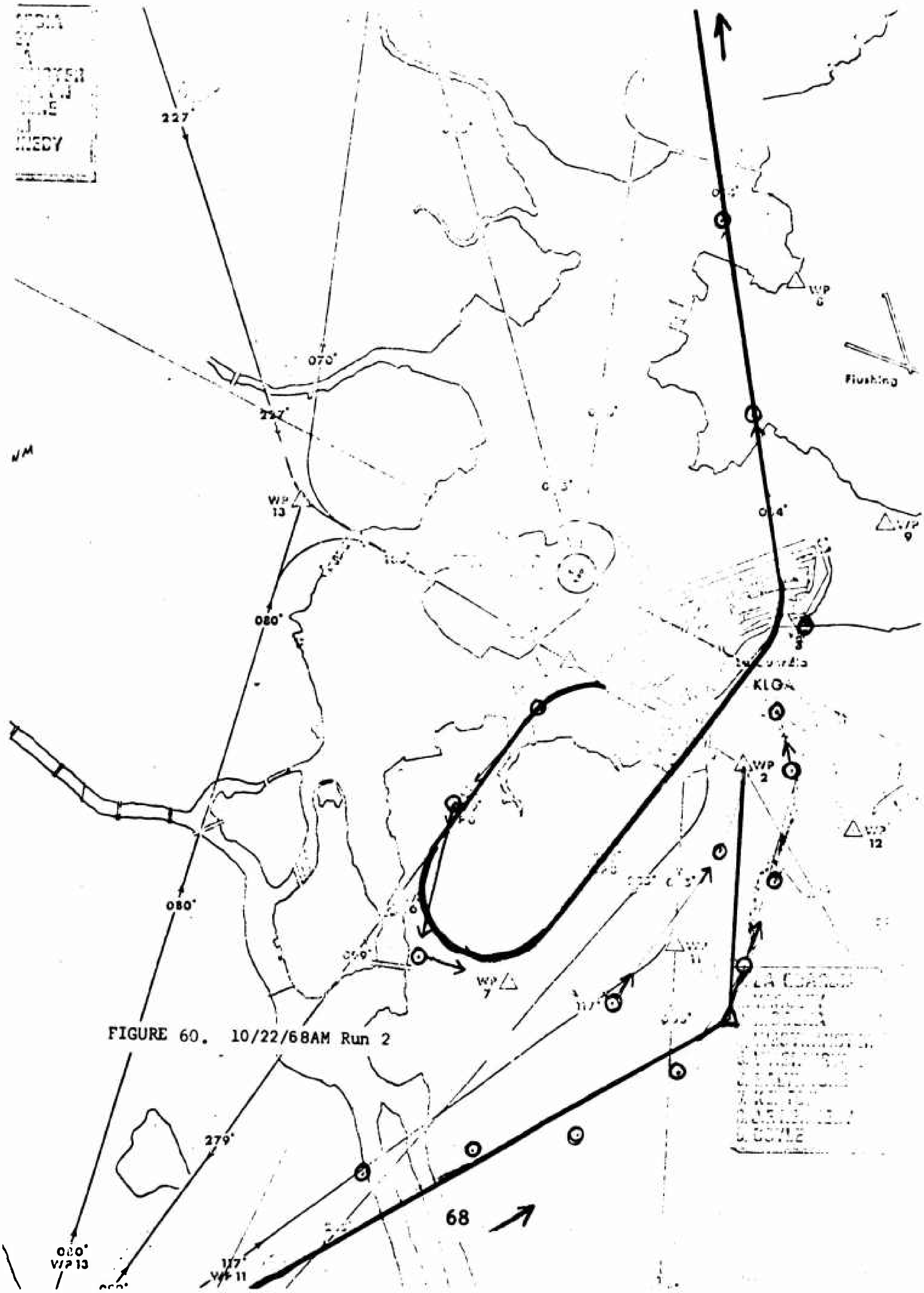


FIGURE 60. 10/22/68AM Run 2

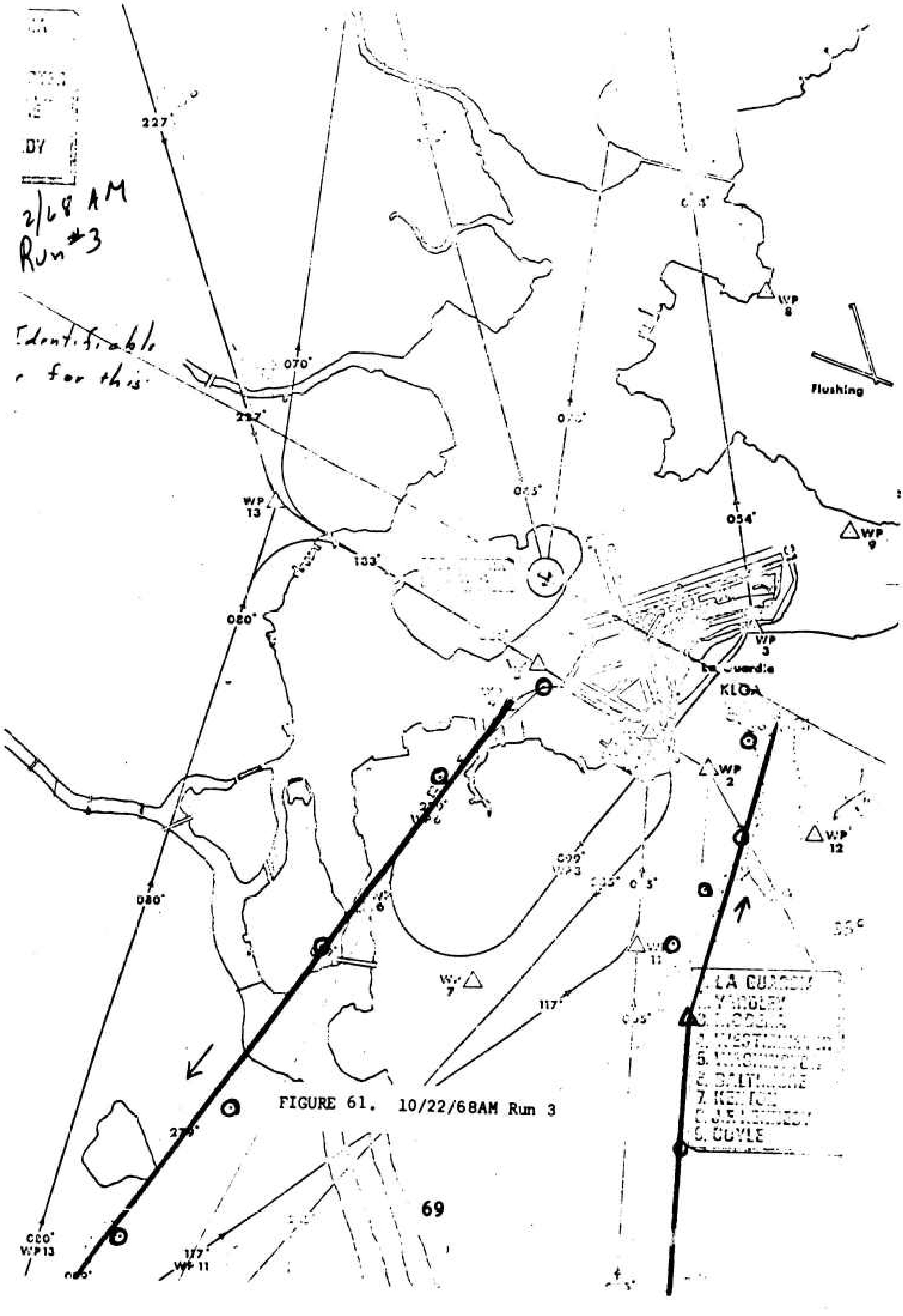


FIGURE 61. 10/22/68AM Run 3

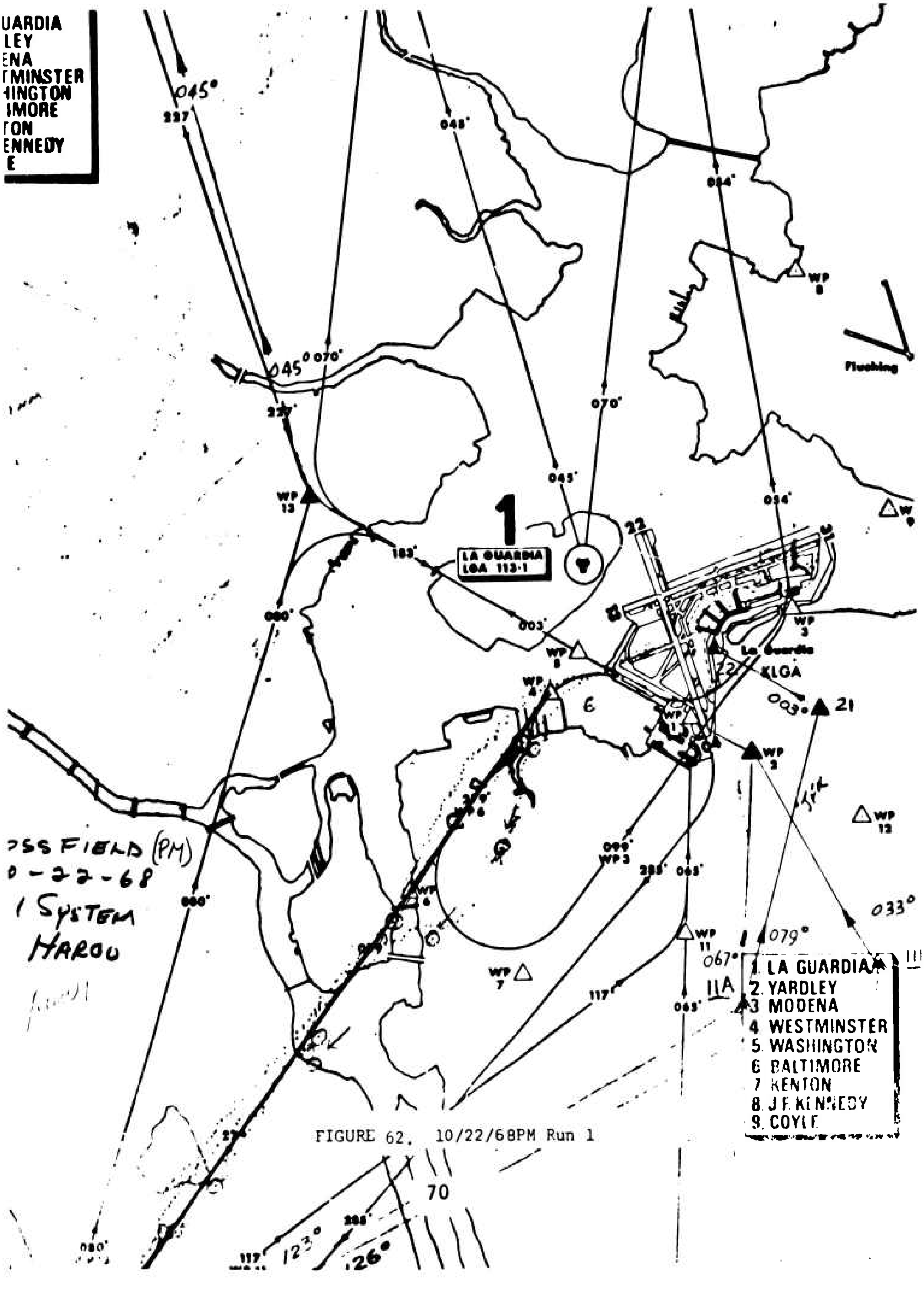


FIGURE 62. 10/22/68PM Run 1

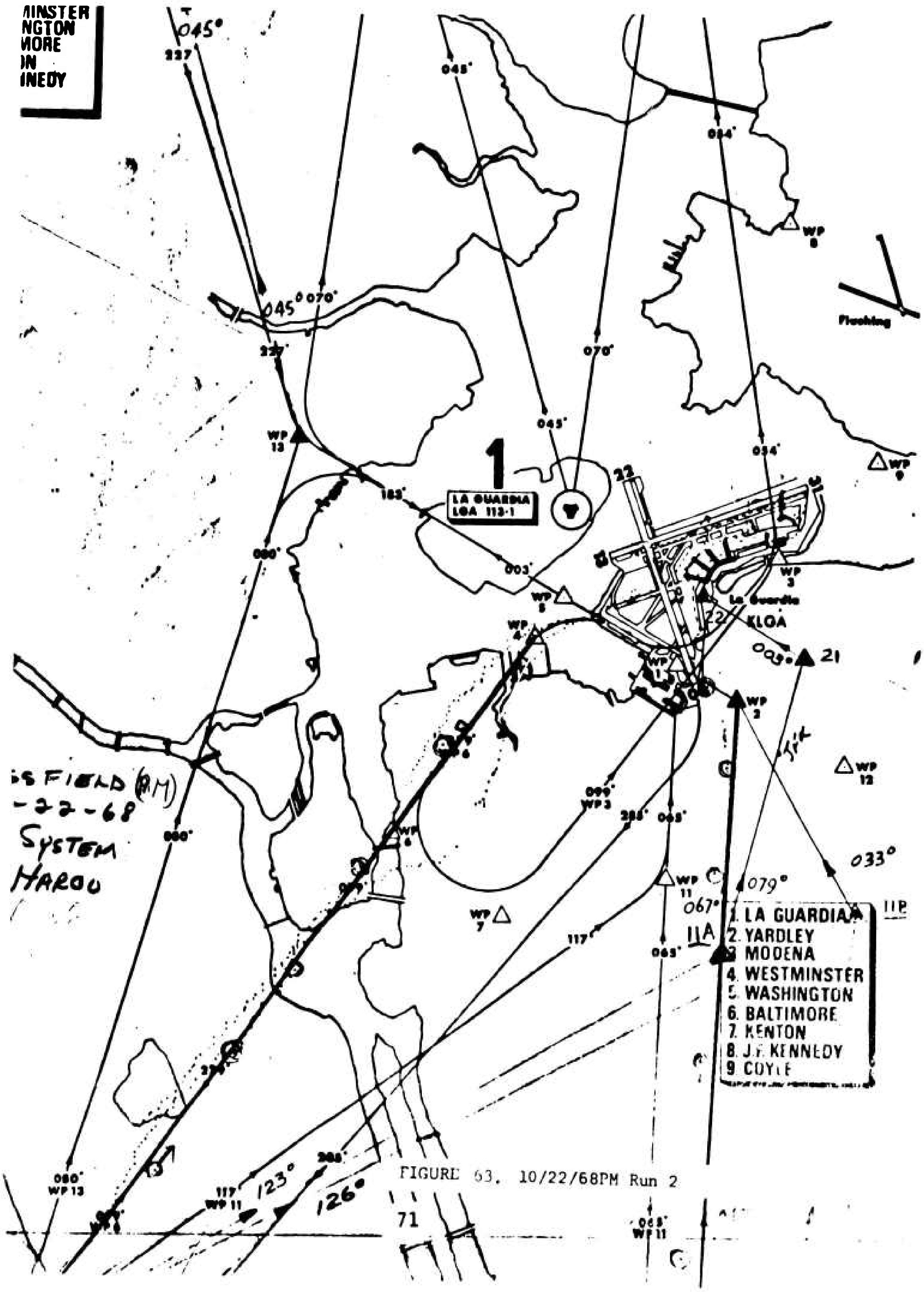


FIGURE 63. 10/22/68PM Run 2

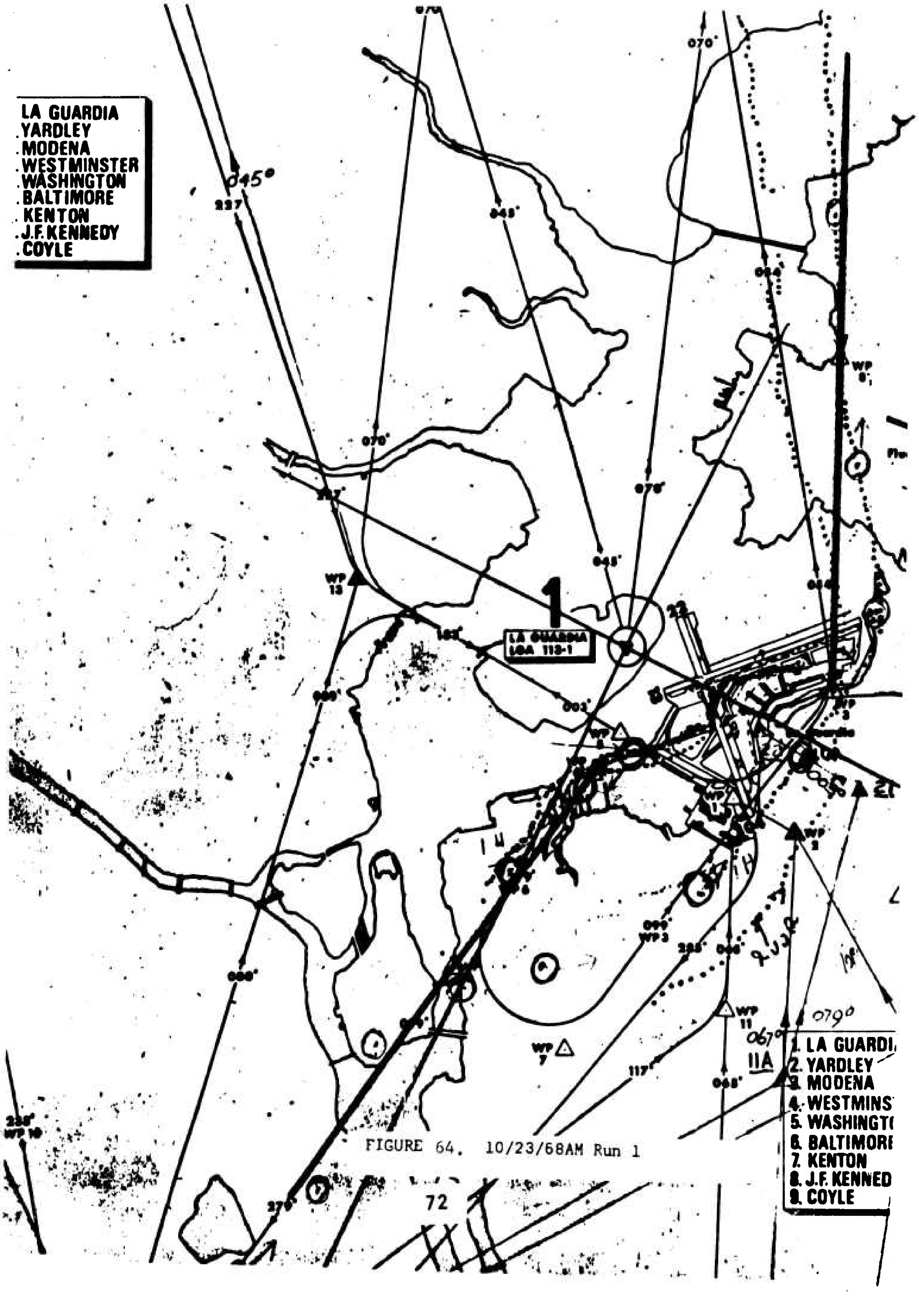


FIGURE 64. 10/23/68AM Run 1

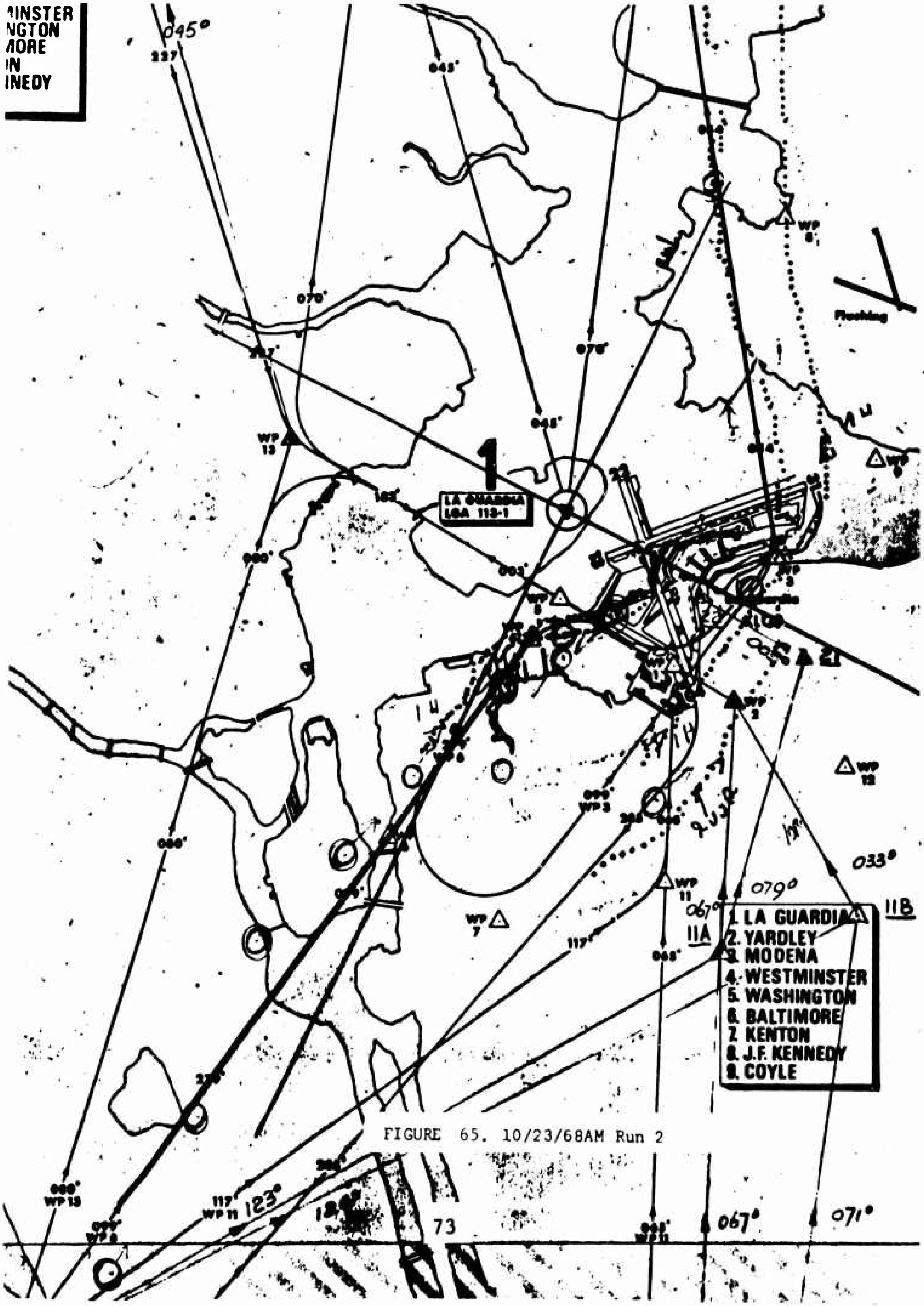


FIGURE 65. 10/23/68AM Run 2

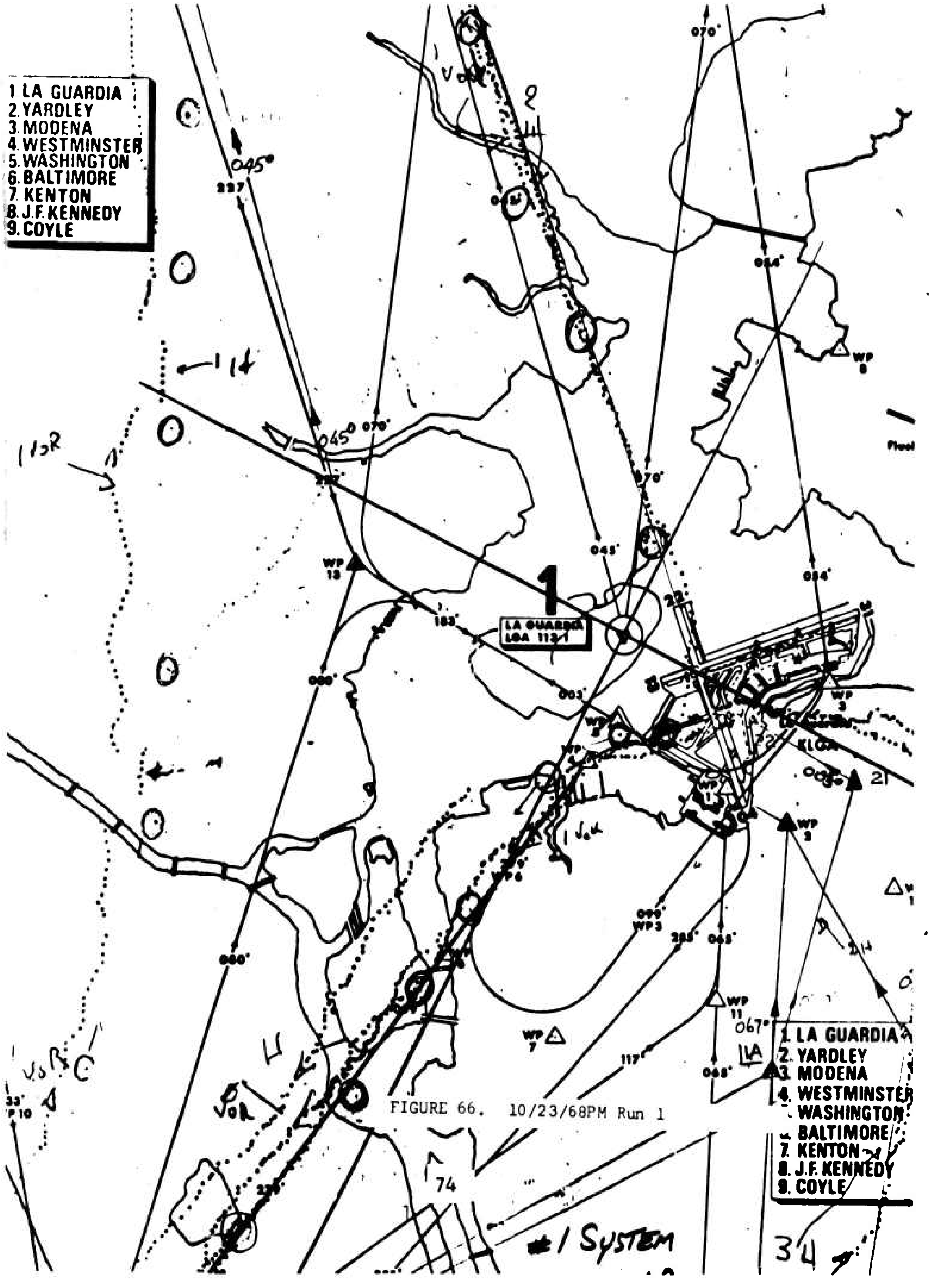


FIGURE 66. 10/23/68PM Run 1

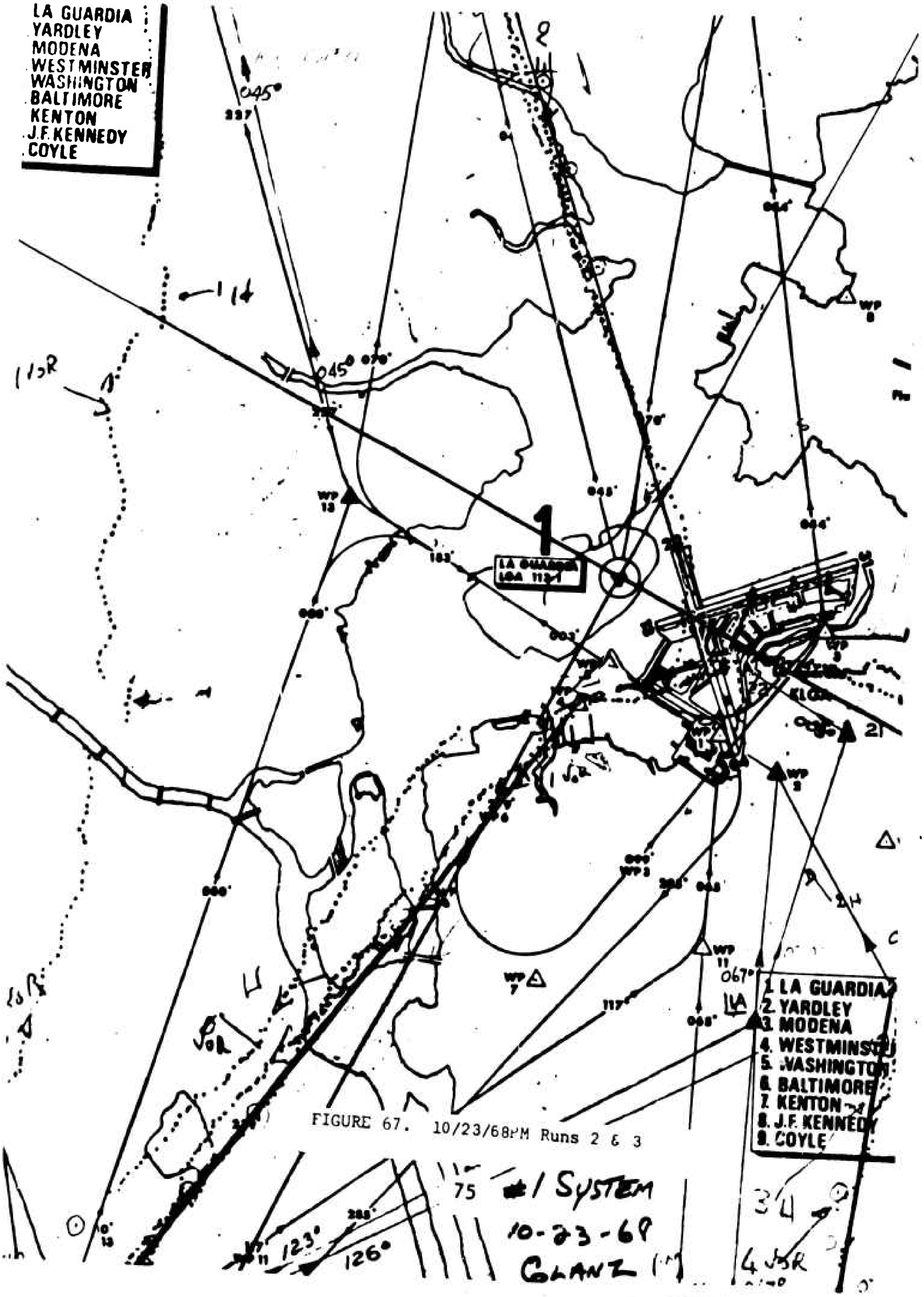


FIGURE 67. 10/23/68PM Runs 2 & 3

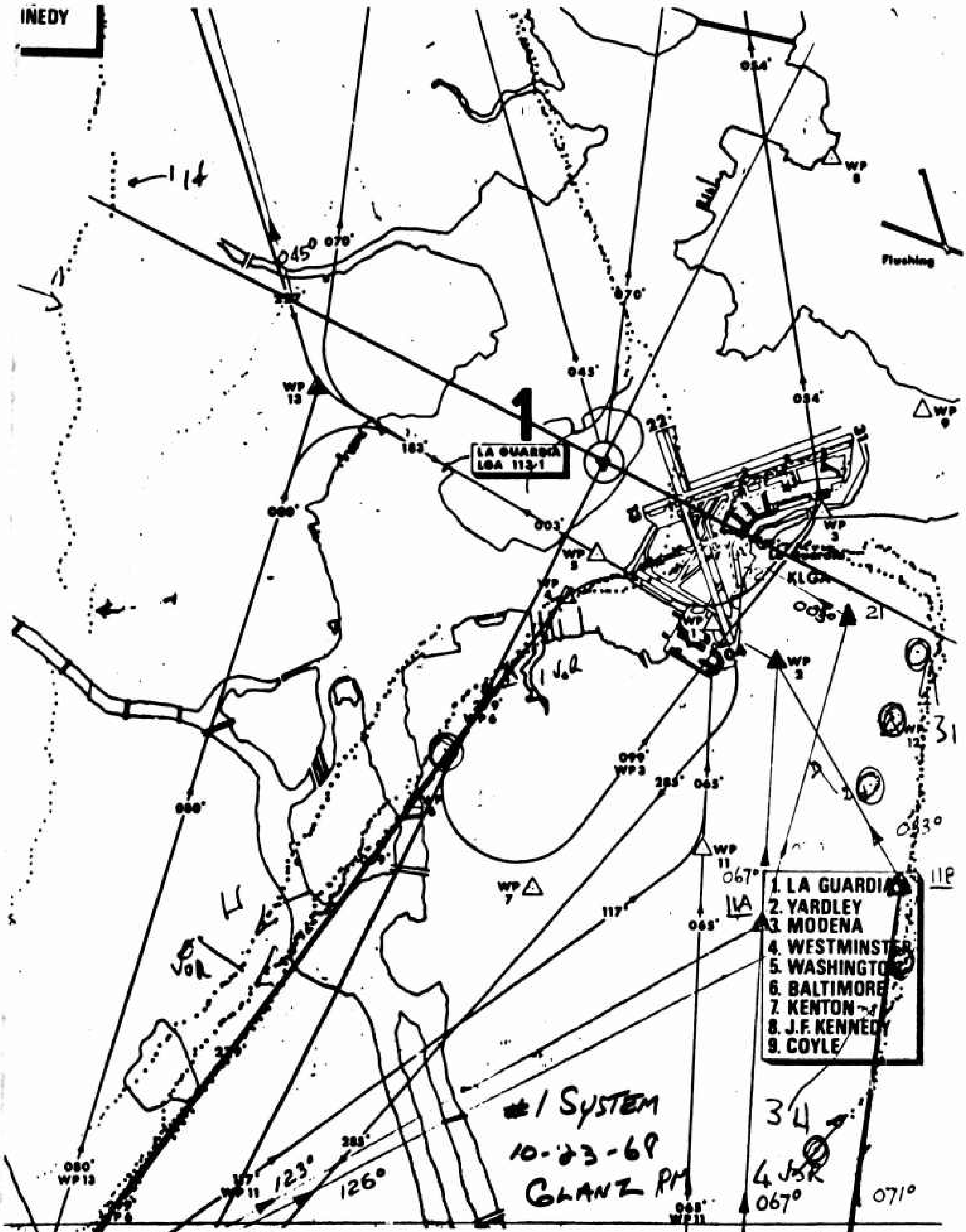


FIGURE 68. 10/23/68PM Run 4

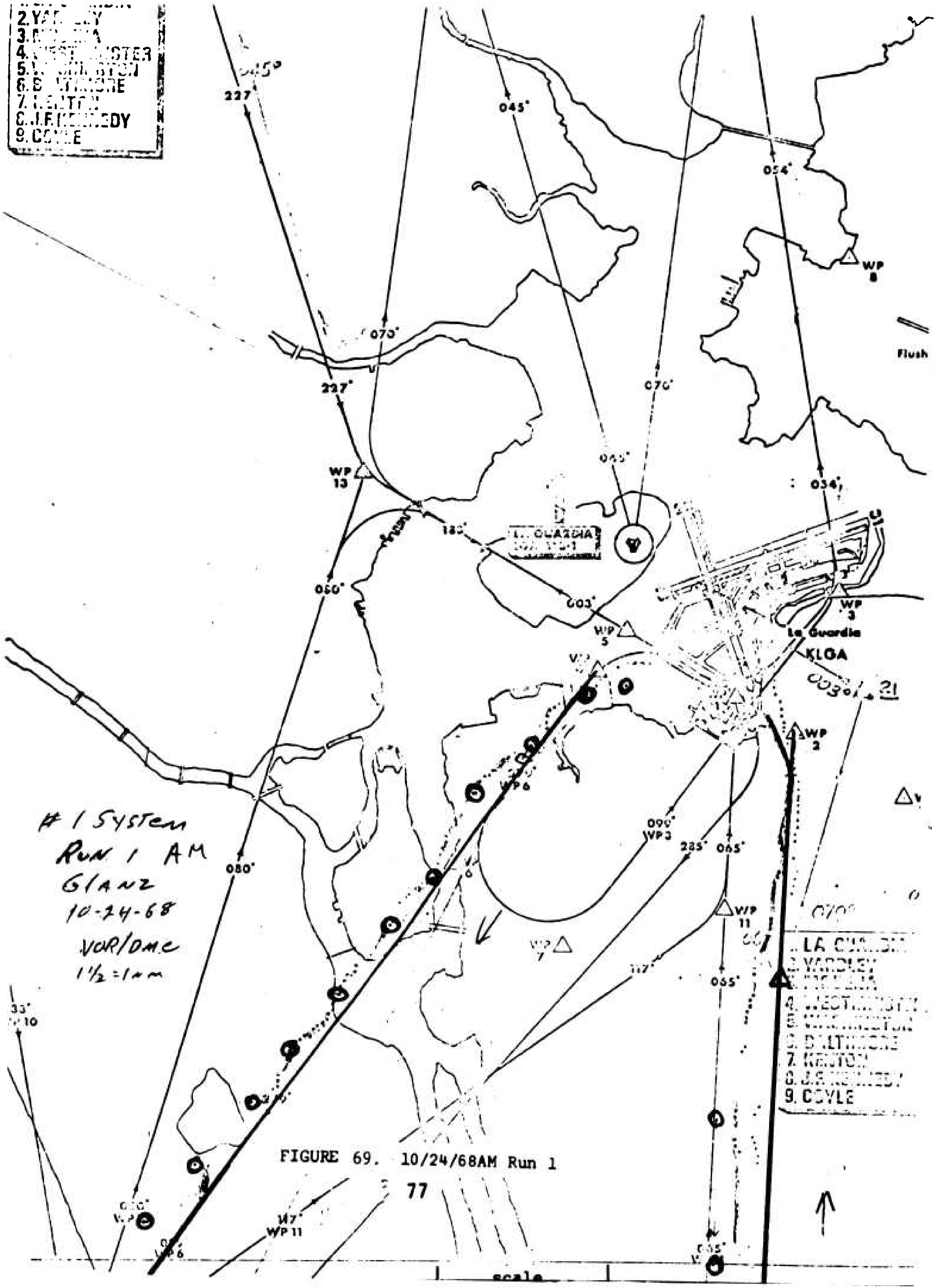


FIGURE 69. 10/24/68AM Run 1

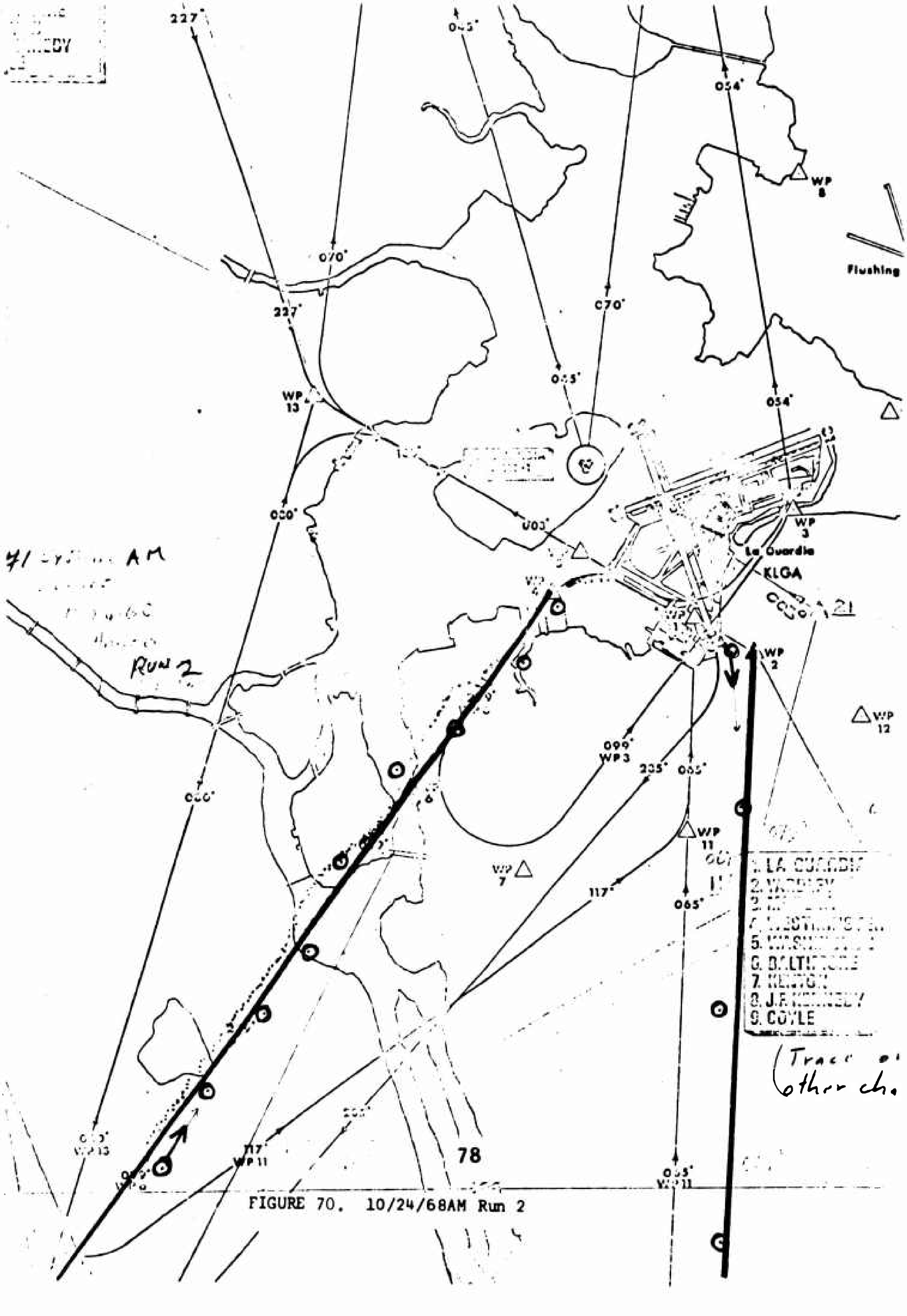


FIGURE 70. 10/24/68AM Run 2

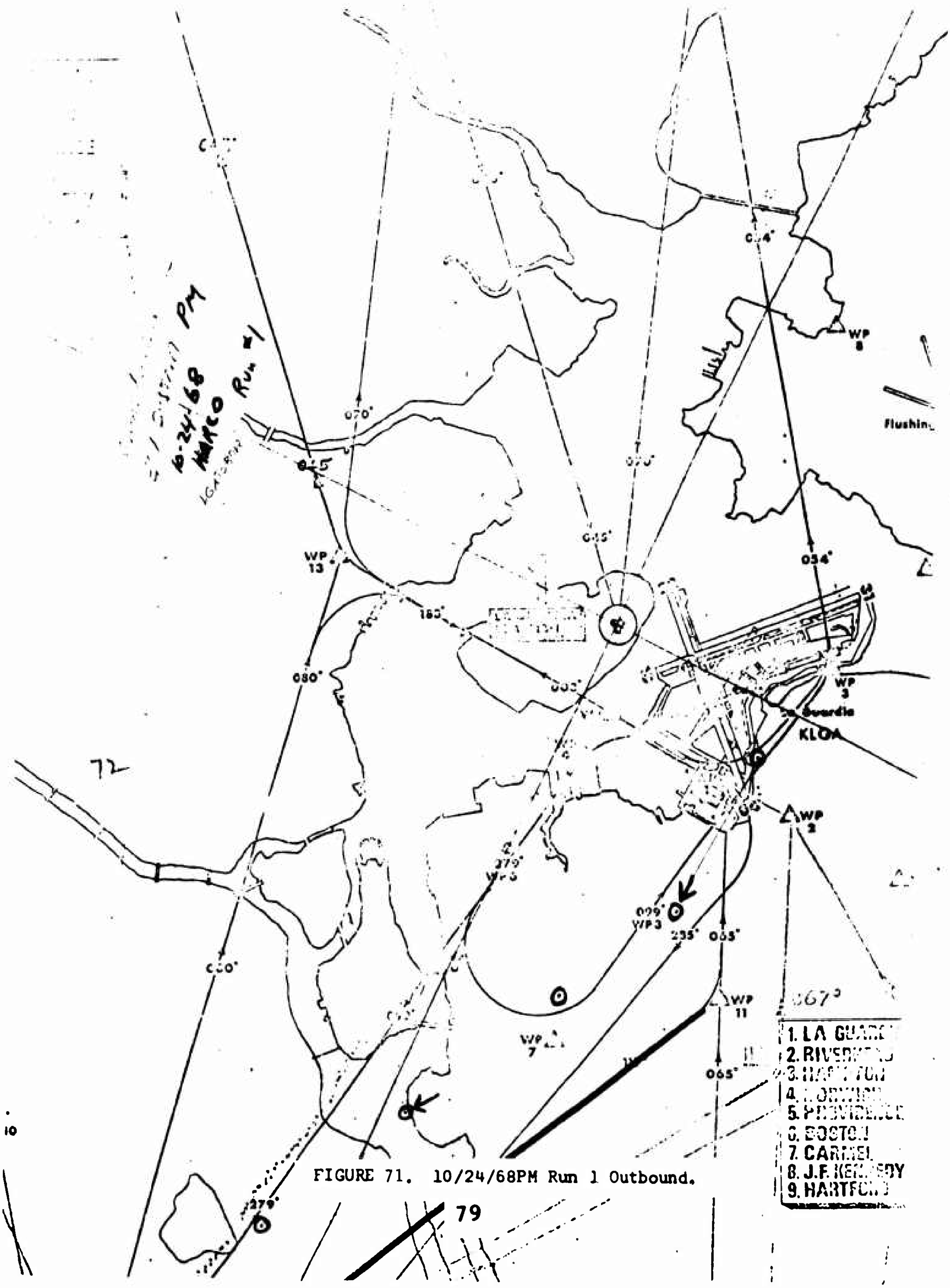


FIGURE 71. 10/24/68PM Run 1 Outbound.

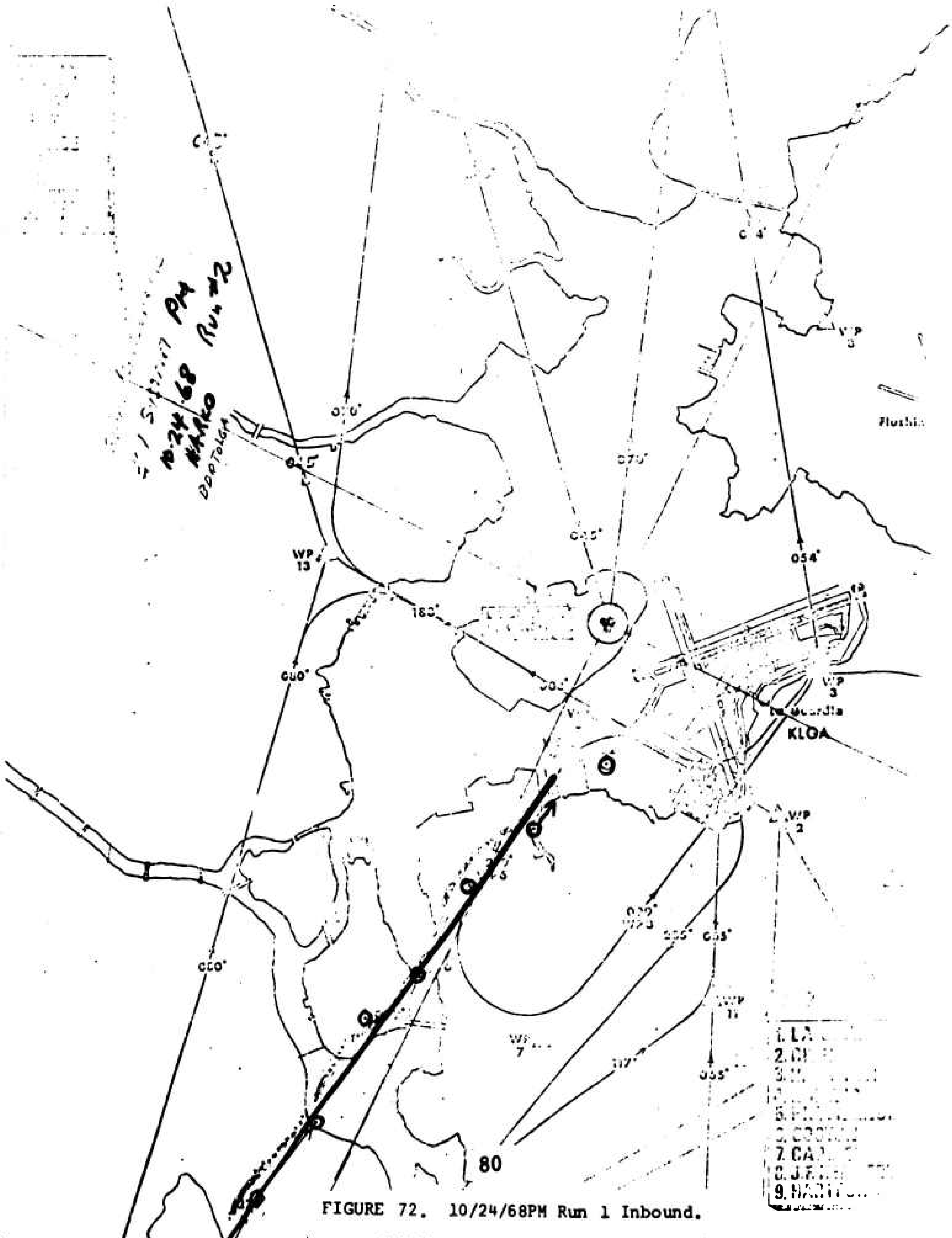


FIGURE 72. 10/24/68PM Run 1 Inbound.

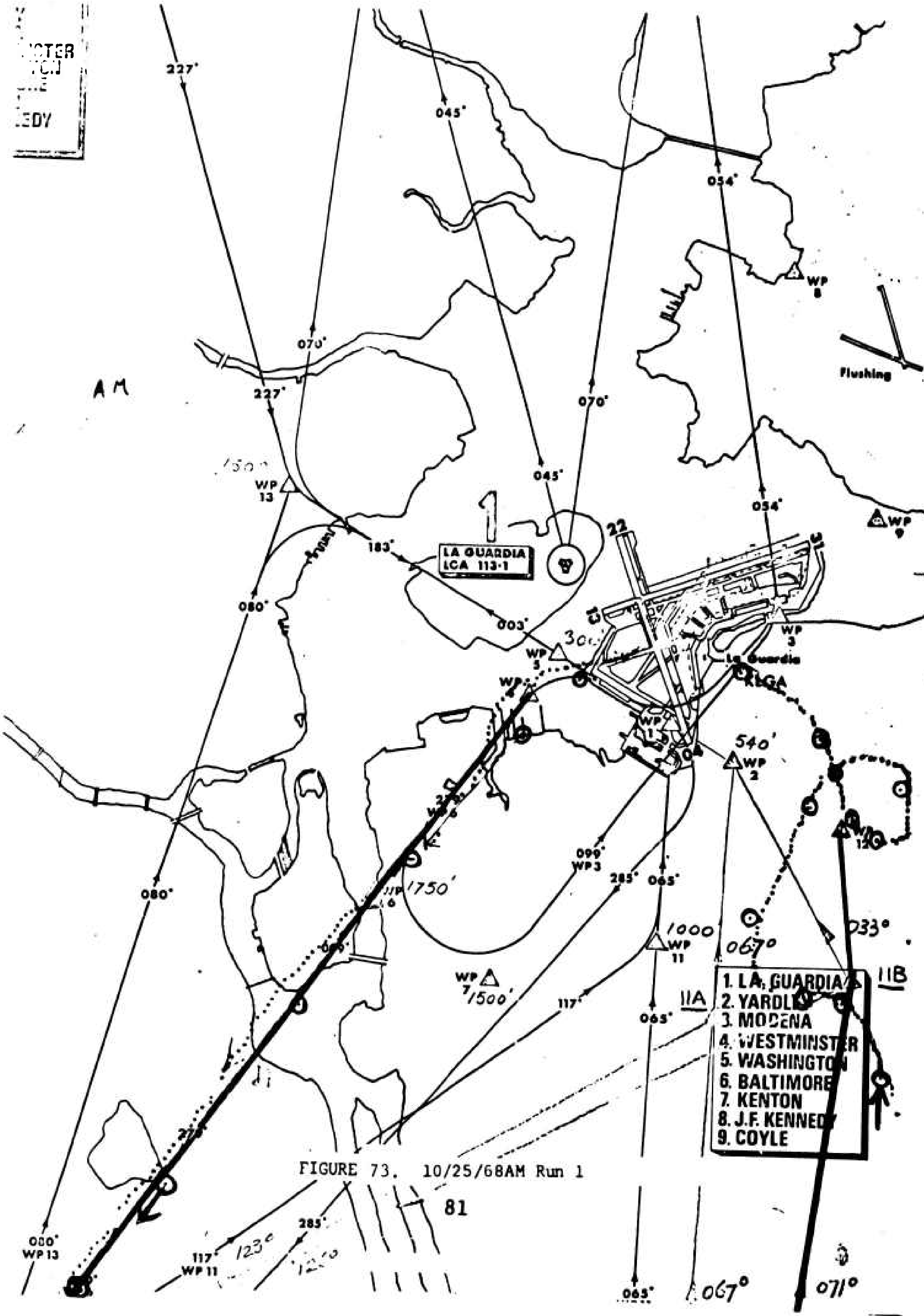


FIGURE 73. 10/25/68AM Run 1

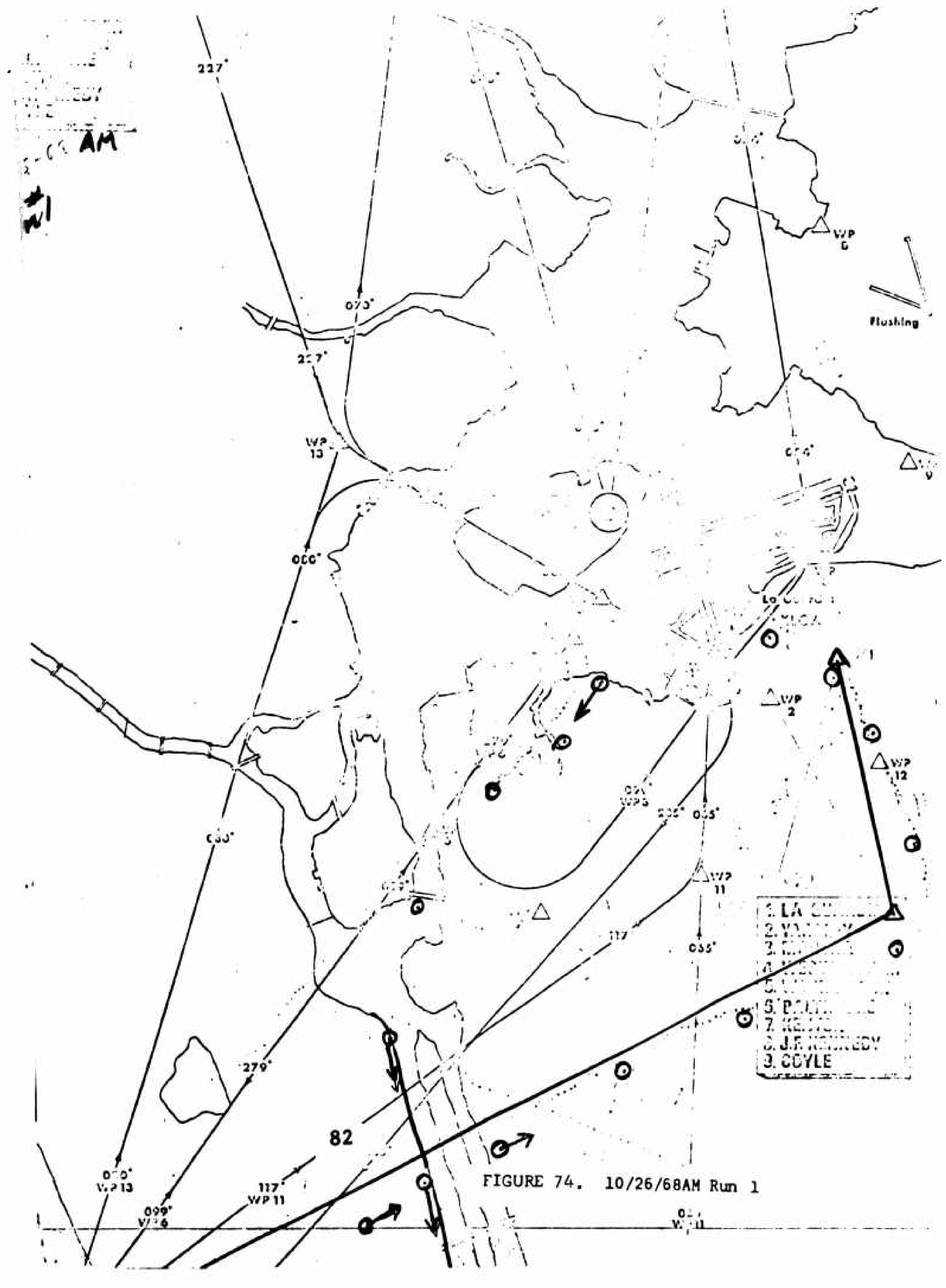


FIGURE 74. 10/26/68AM Run 1

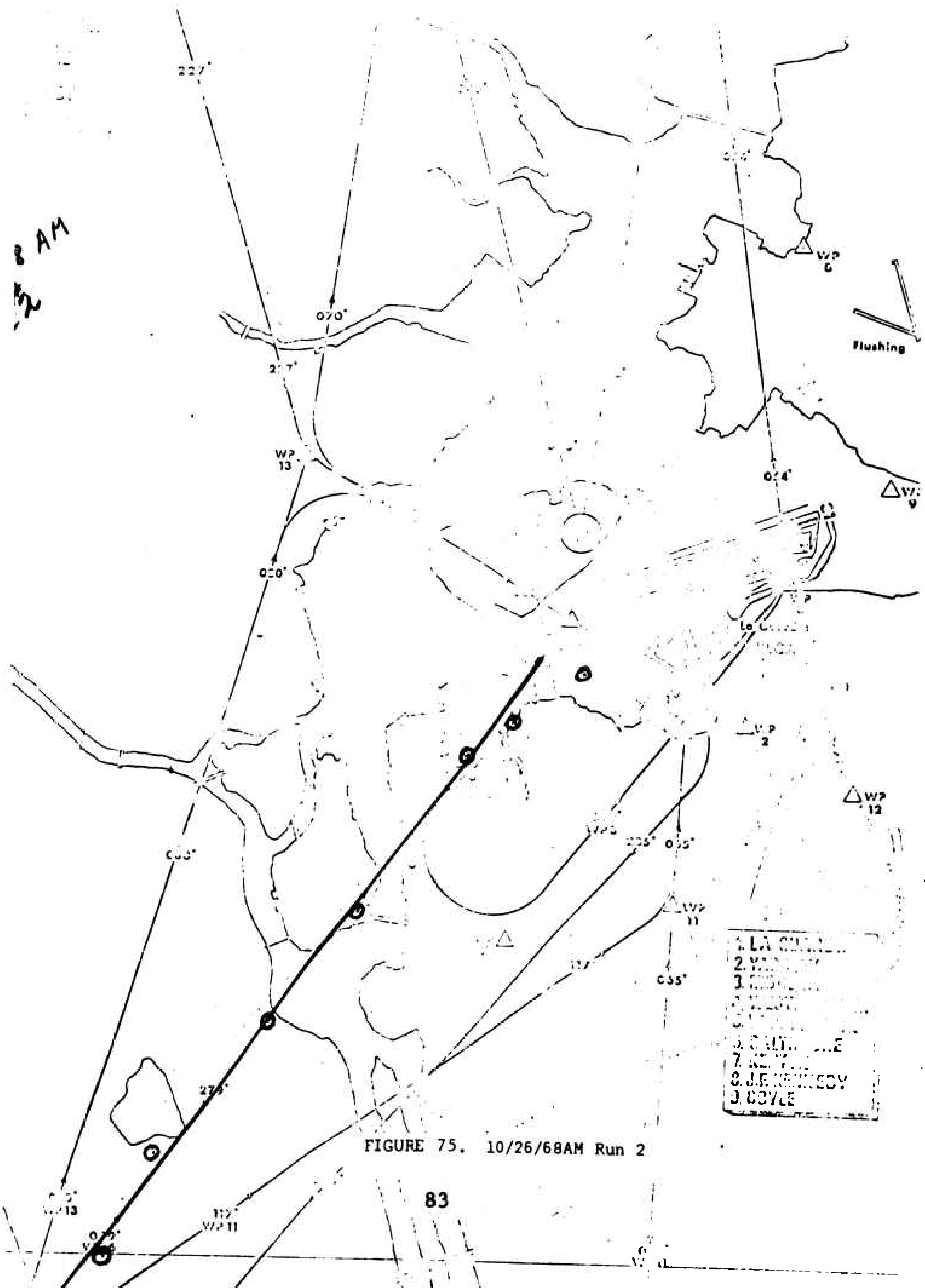


FIGURE 75. 10/26/68AM Run 2

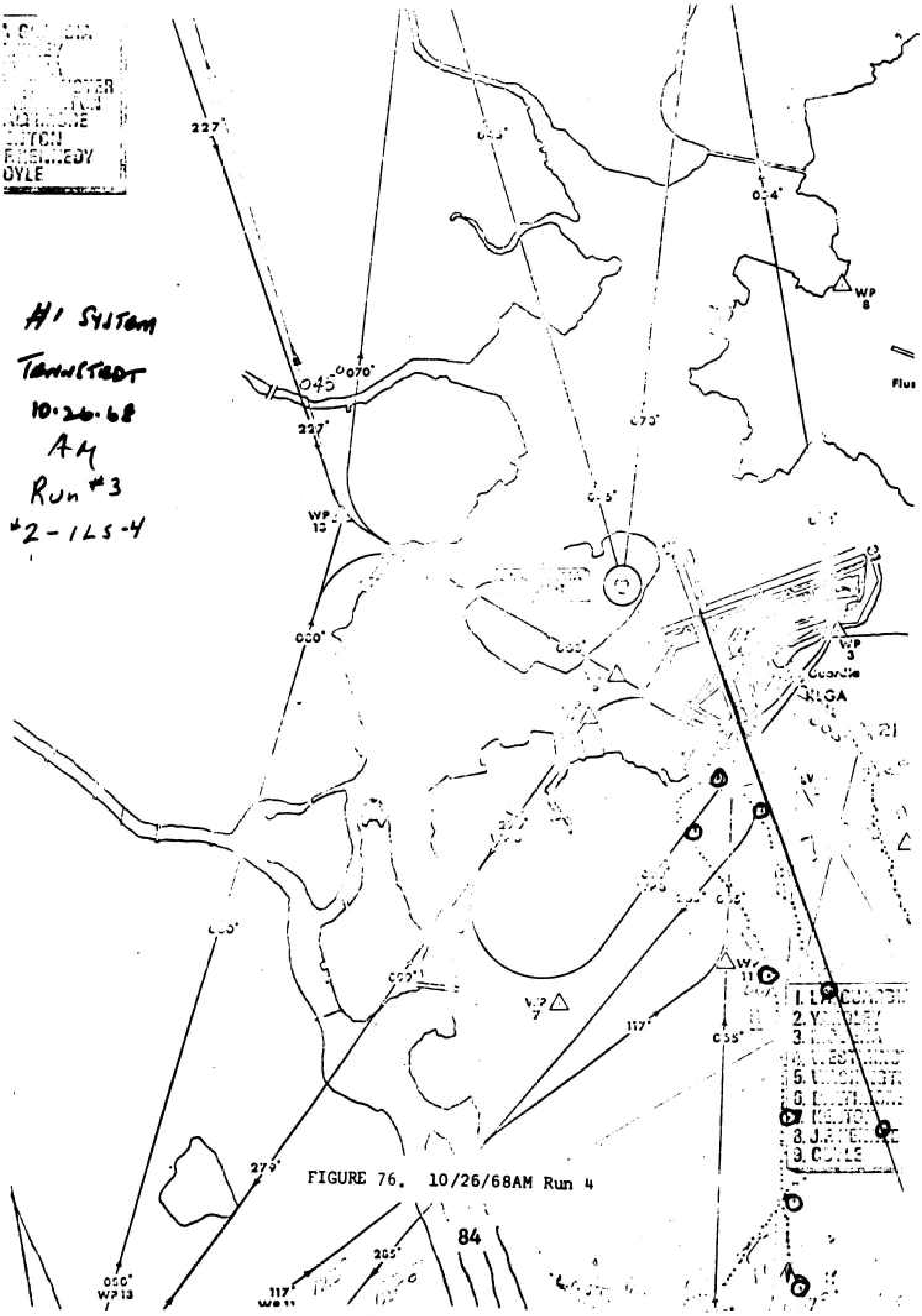


FIGURE 76. 10/26/68AM Run 4

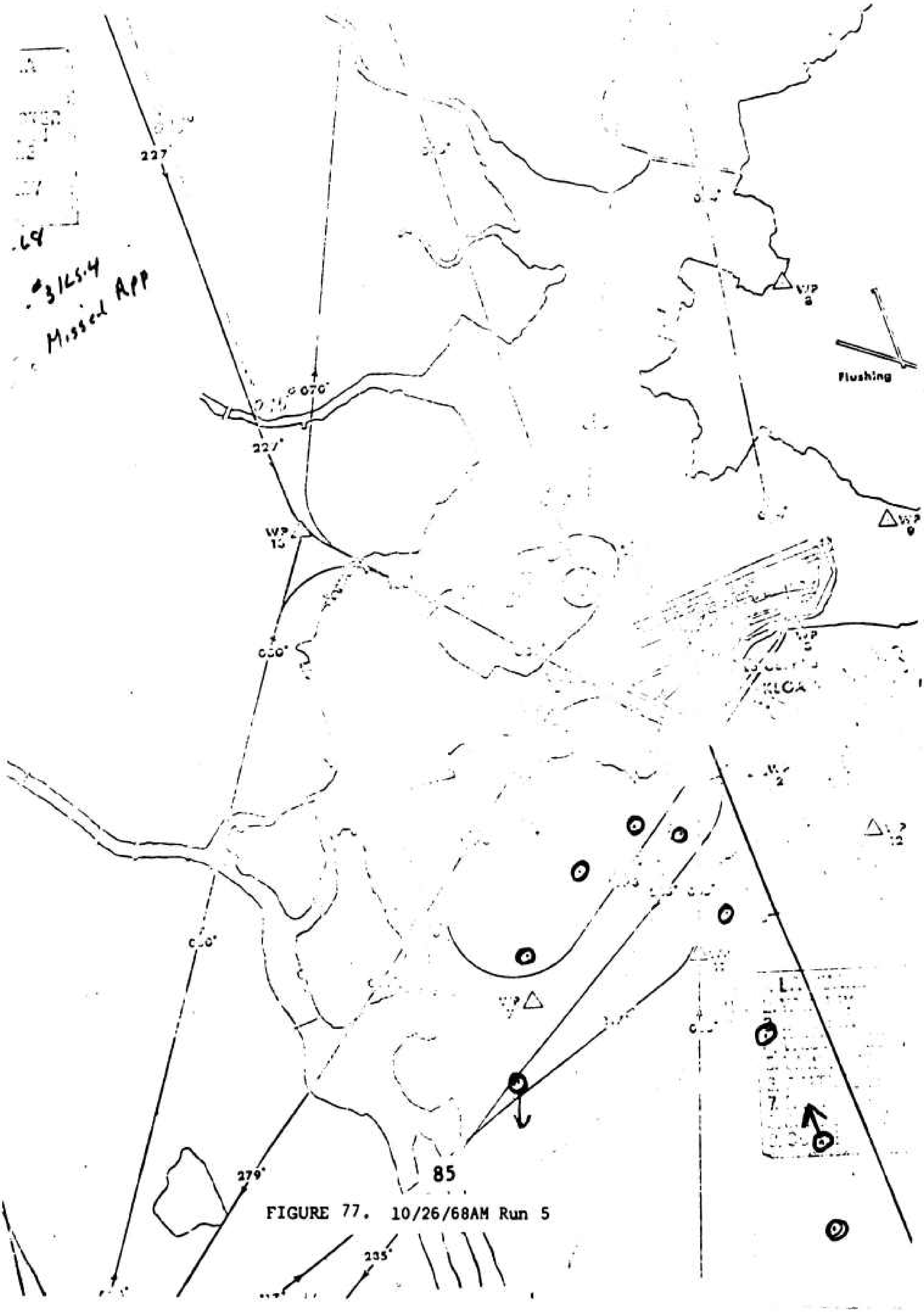


FIGURE 77. 10/26/68AM Run 5

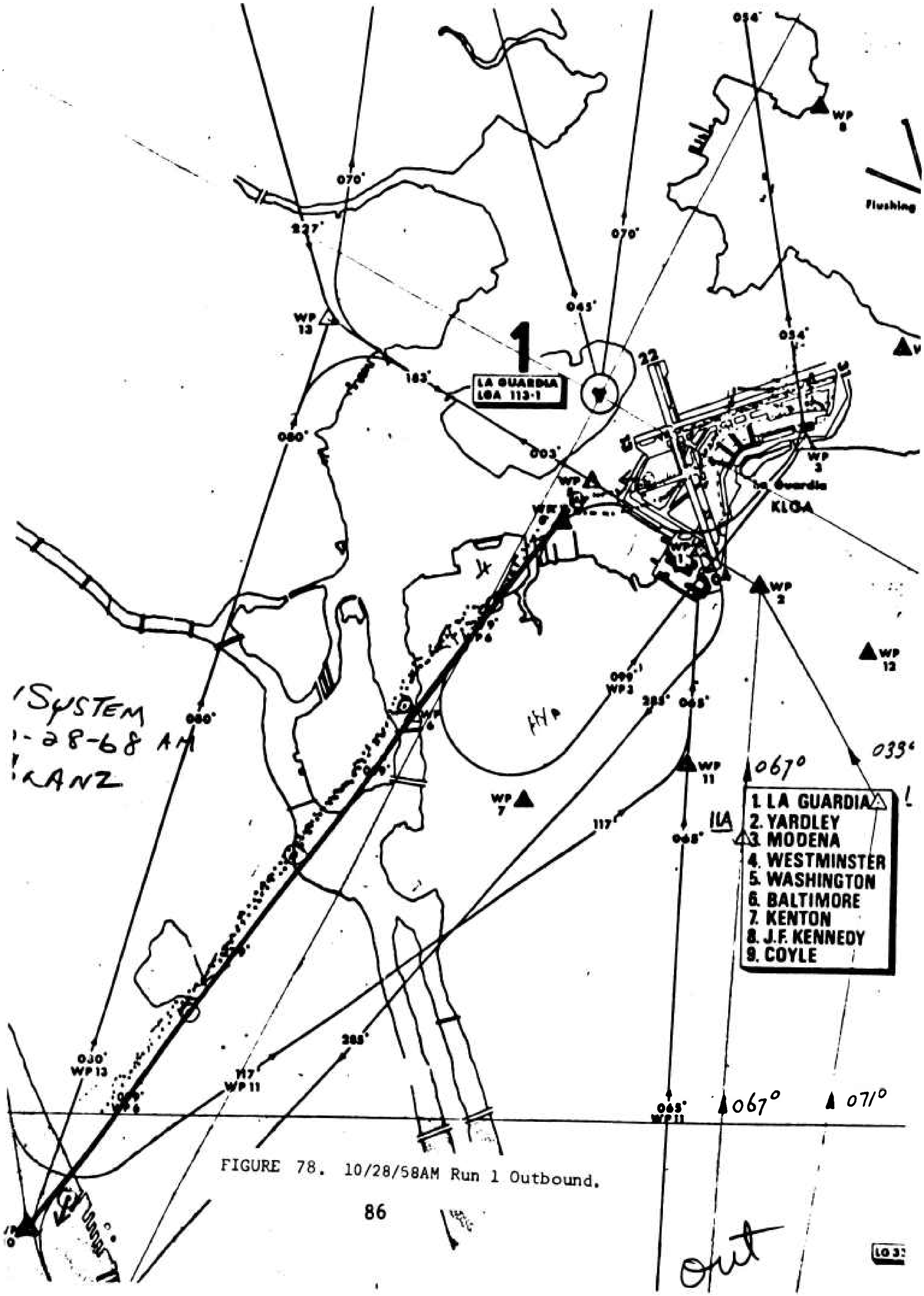


FIGURE 78. 10/28/58AM Run 1 Outbound.

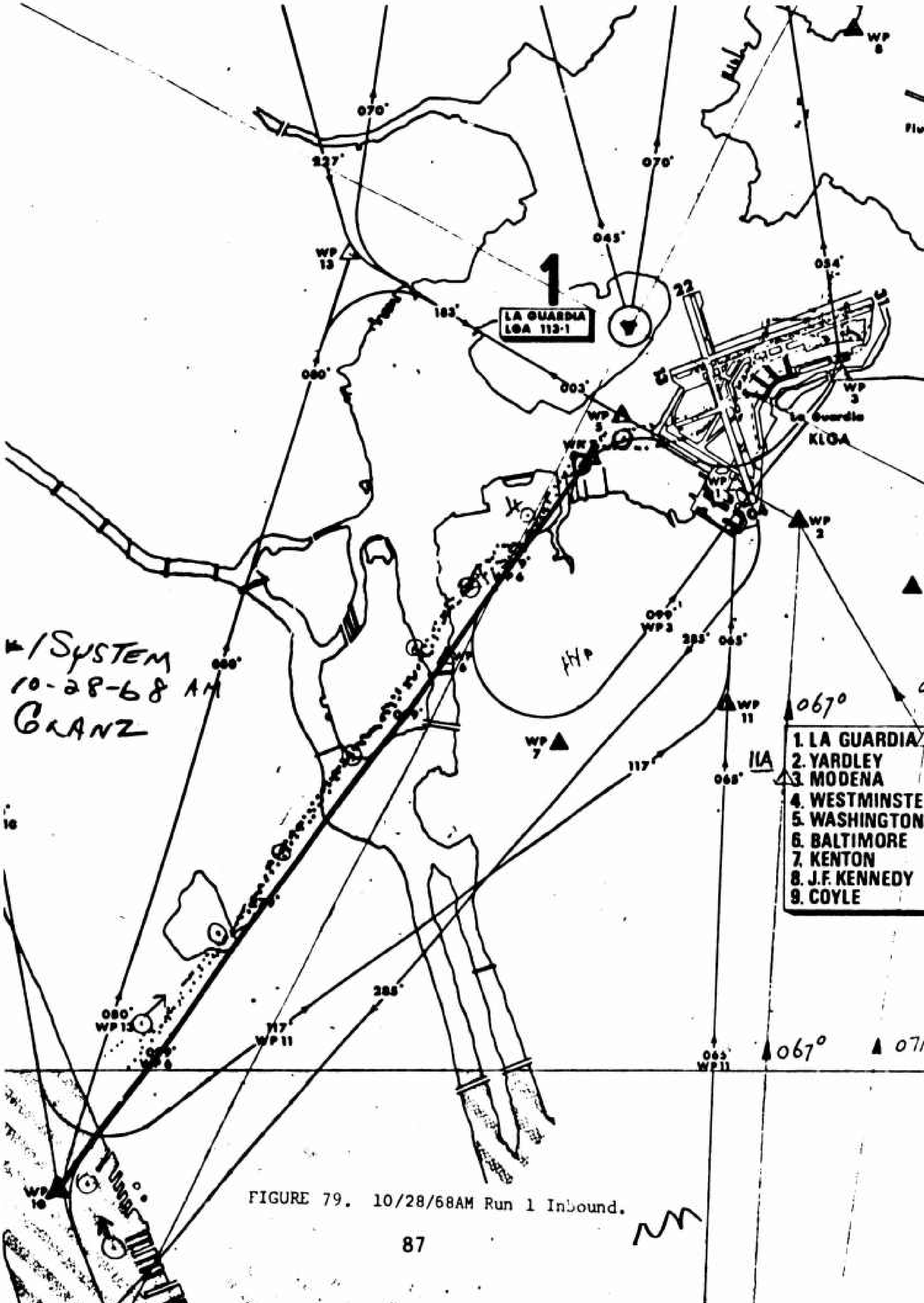


FIGURE 79. 10/28/68AM Run 1 Inbound.

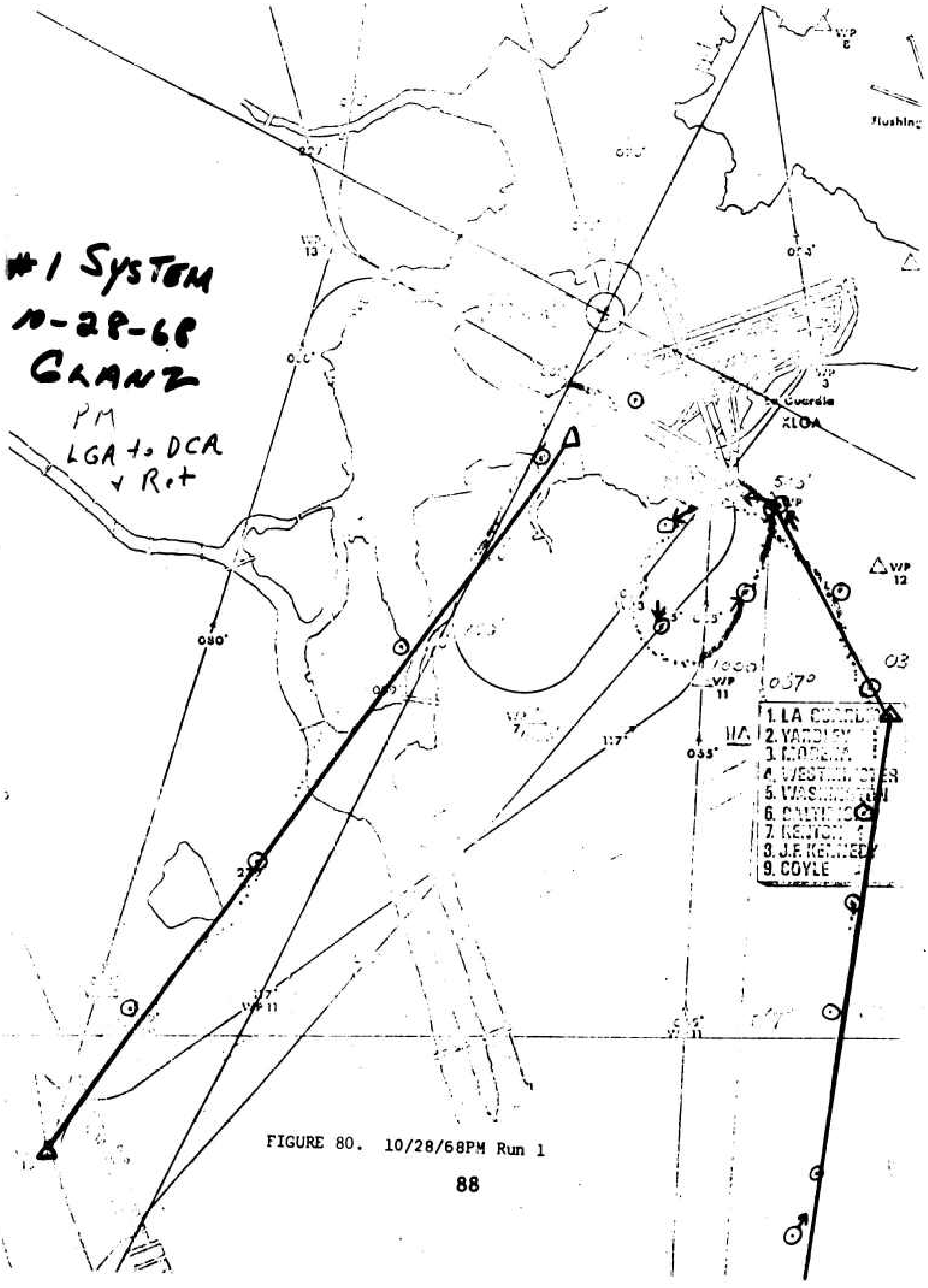


FIGURE 80. 10/28/68PM Run 1

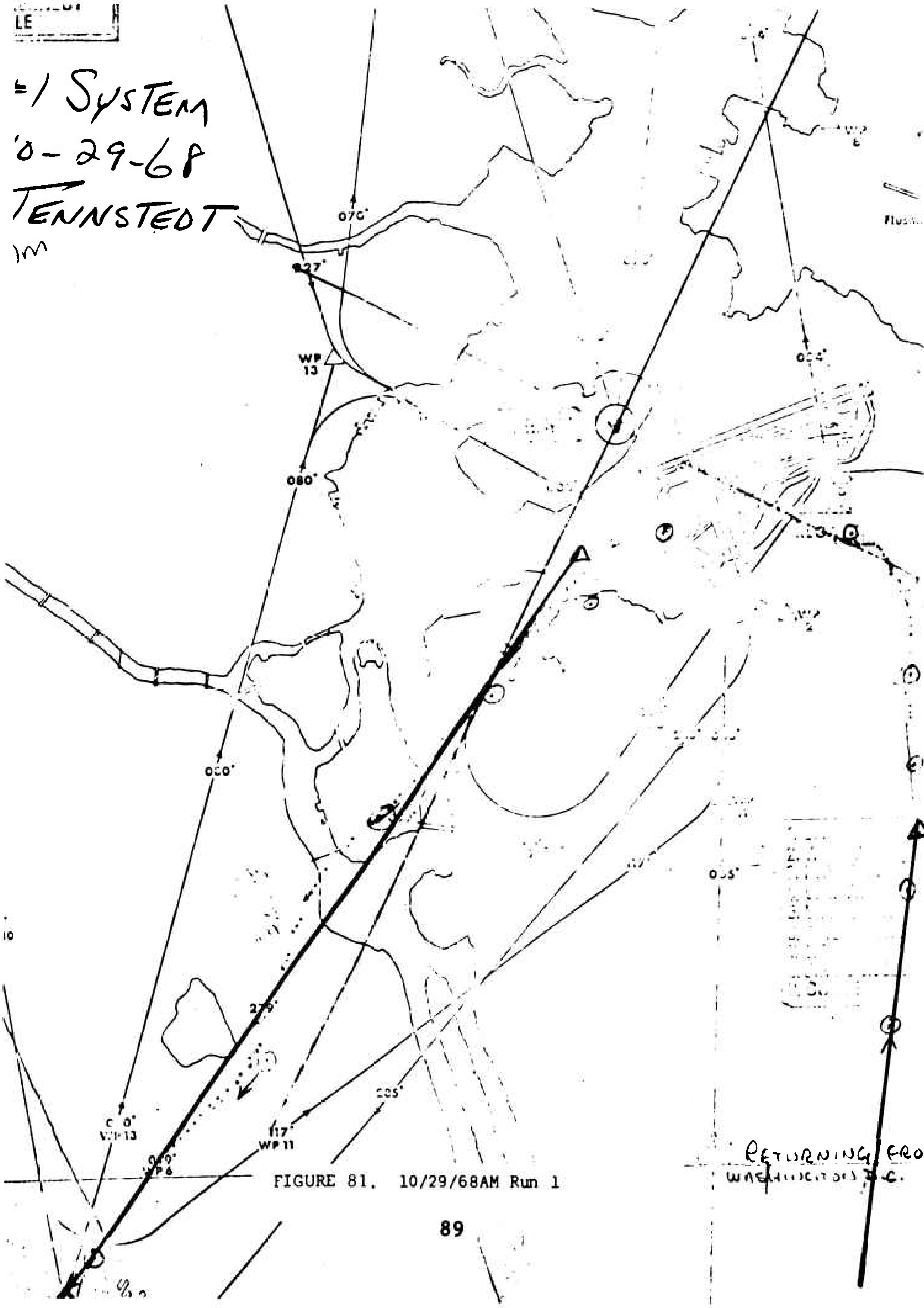


FIGURE 81. 10/29/68AM Run 1

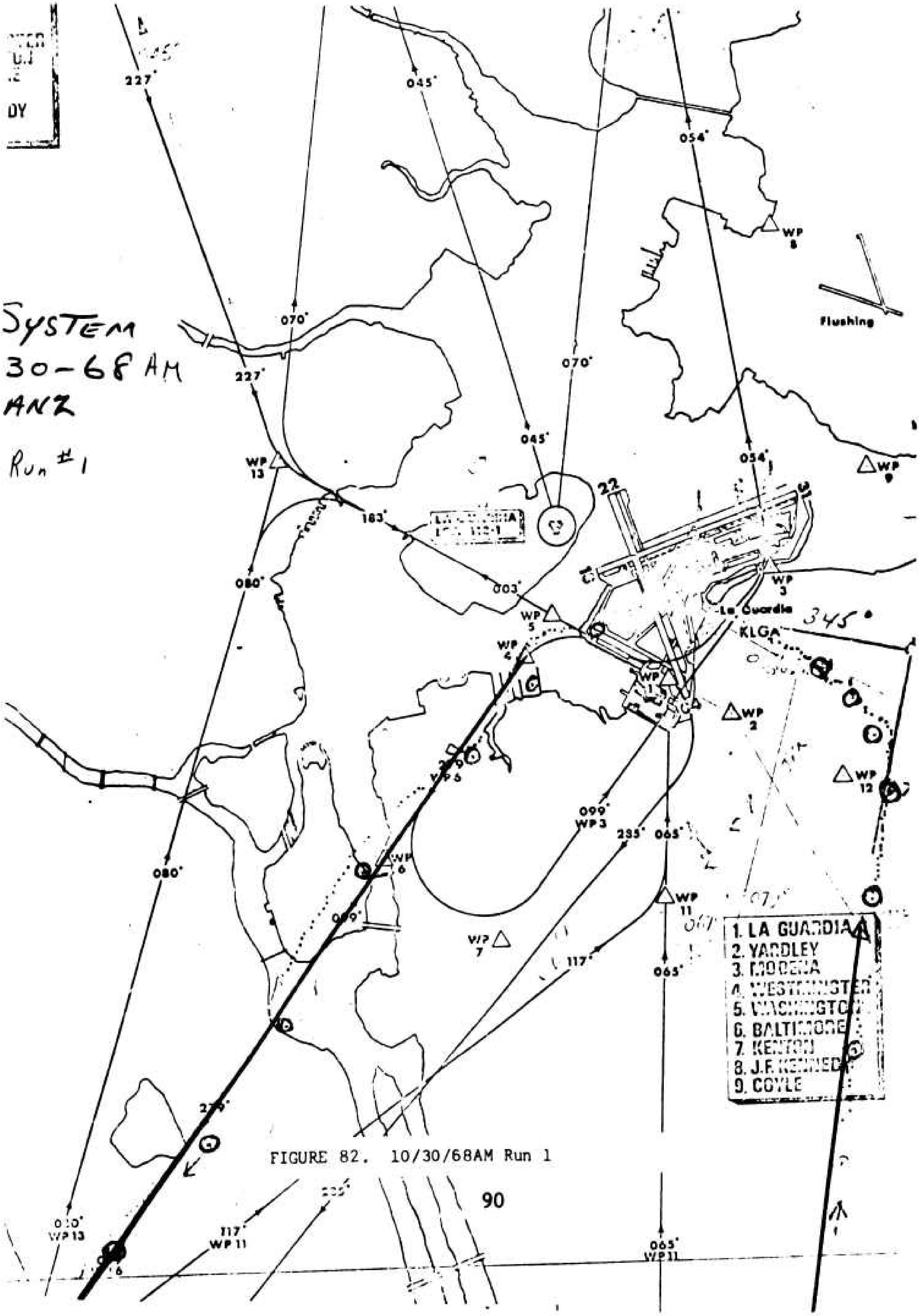


FIGURE 82. 10/30/68AM Run 1

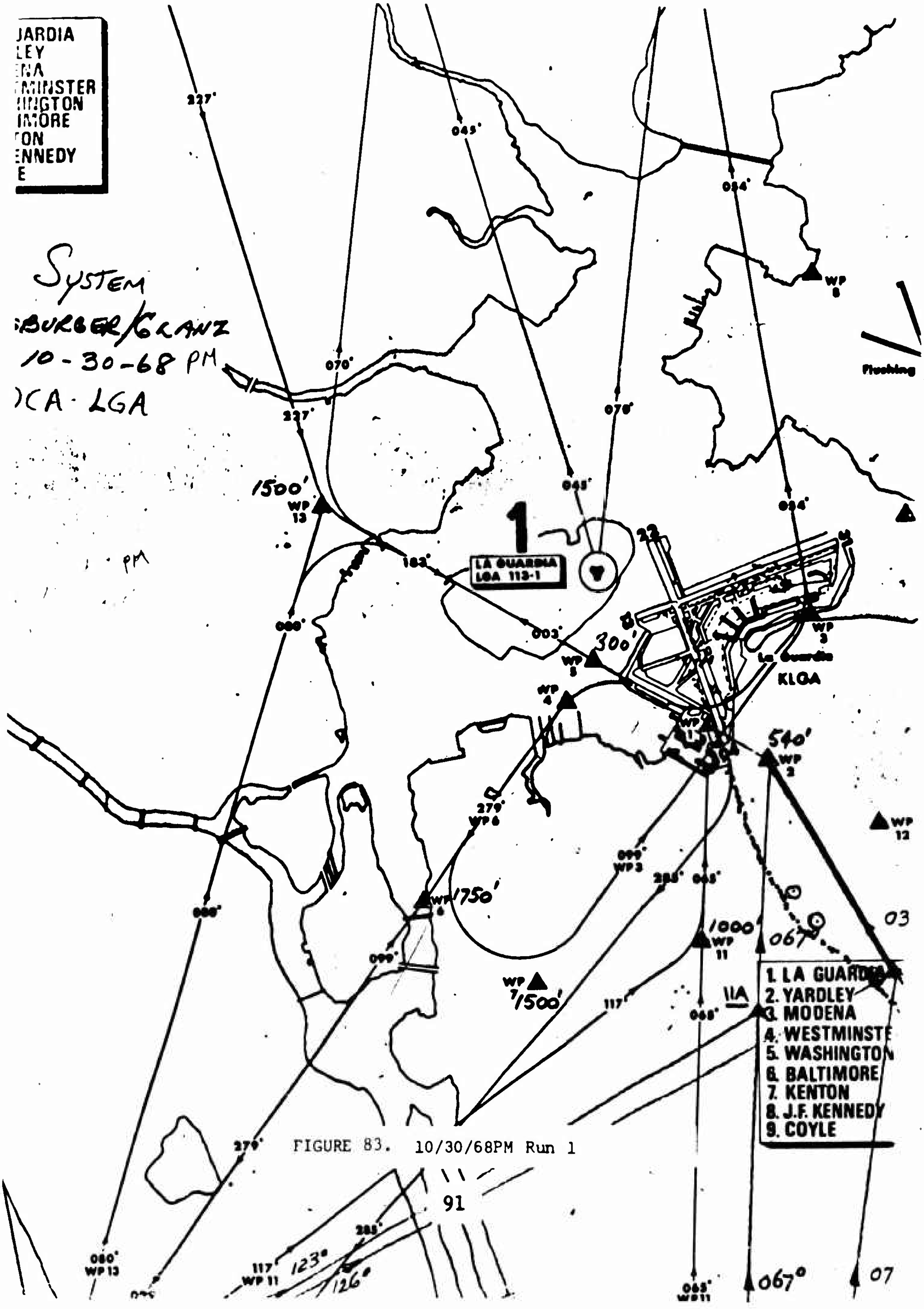


FIGURE 83. 10/30/68PM Run 1

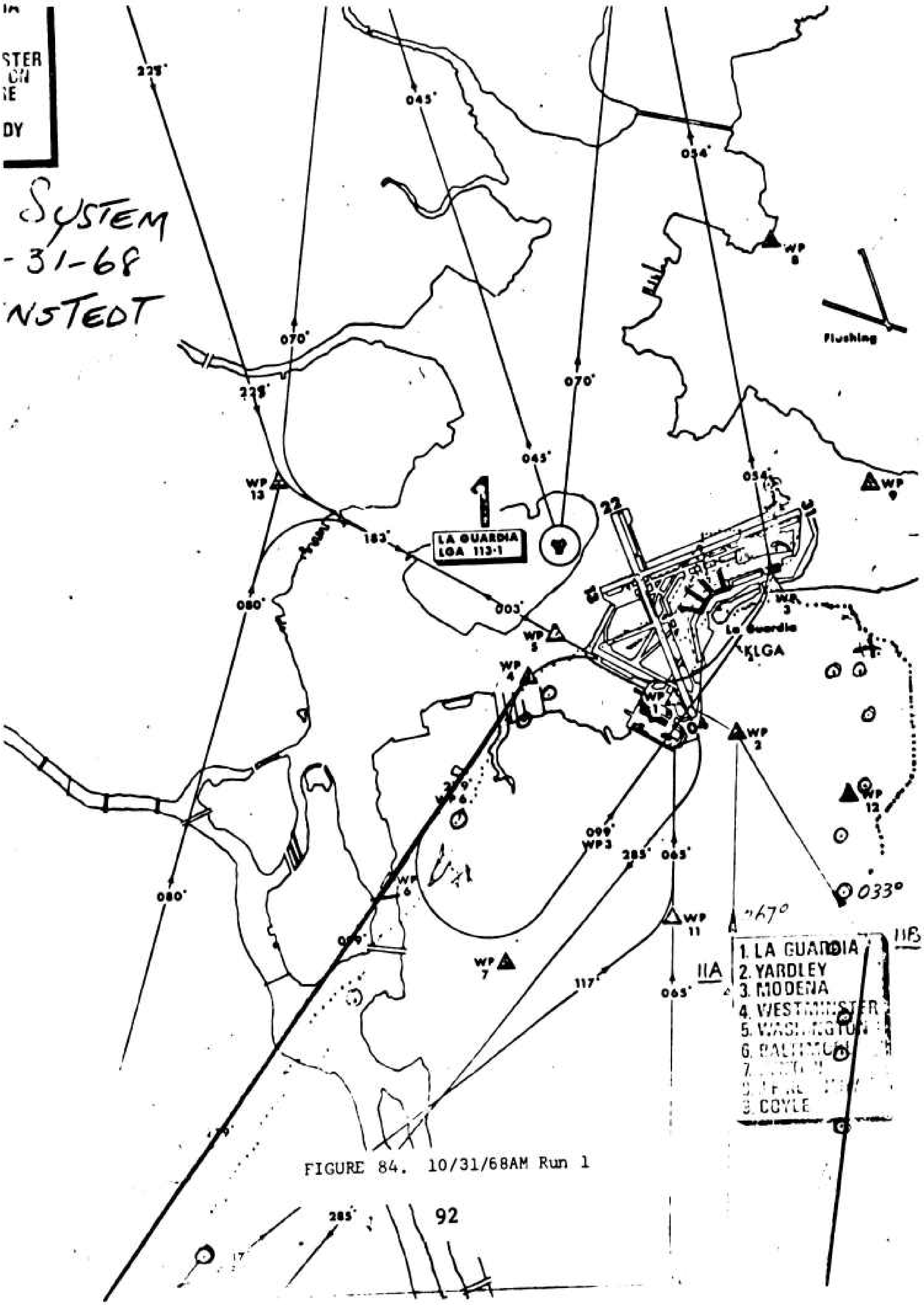


FIGURE 84. 10/31/68AM Run 1

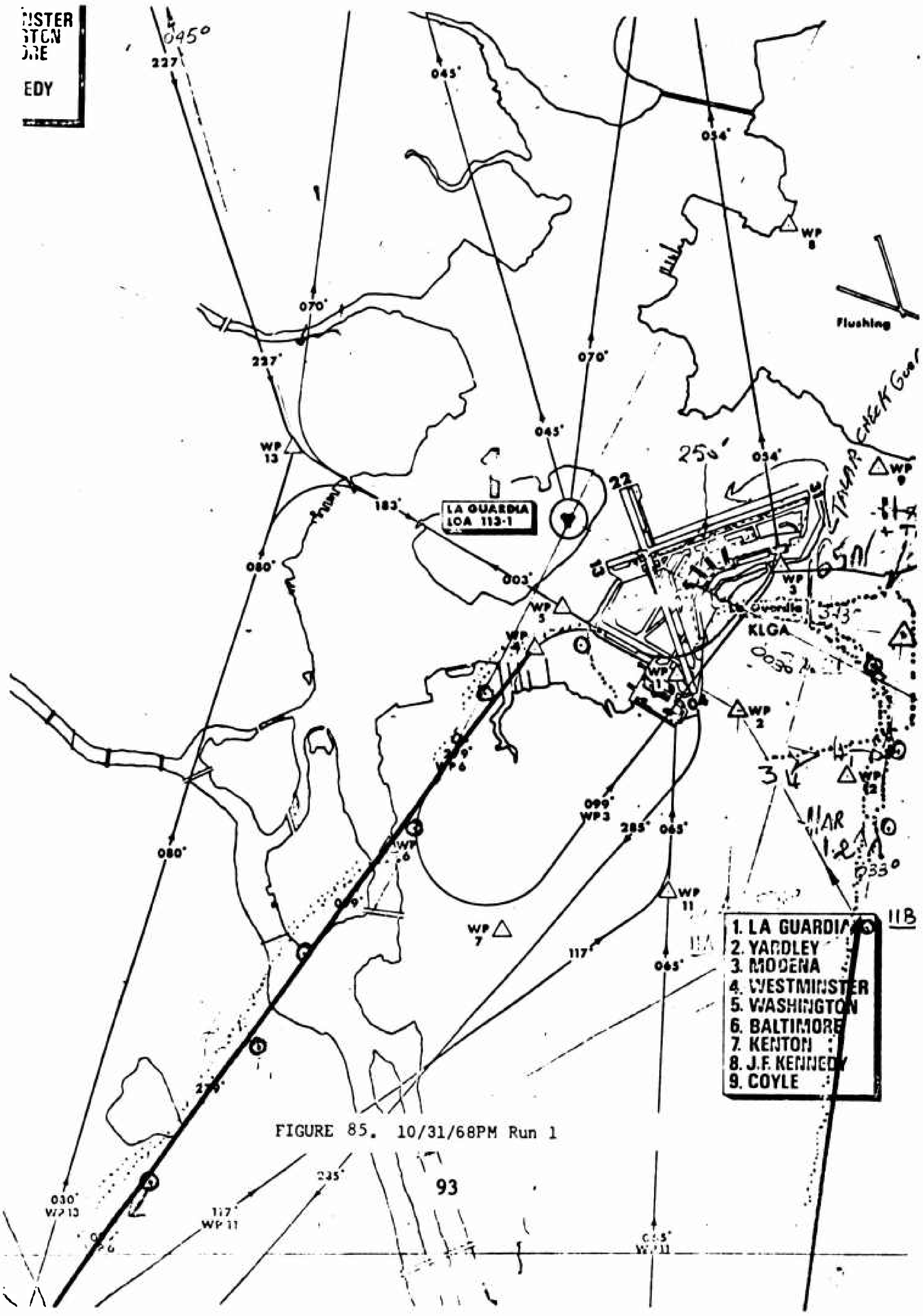


FIGURE 85. 10/31/68PM Run 1

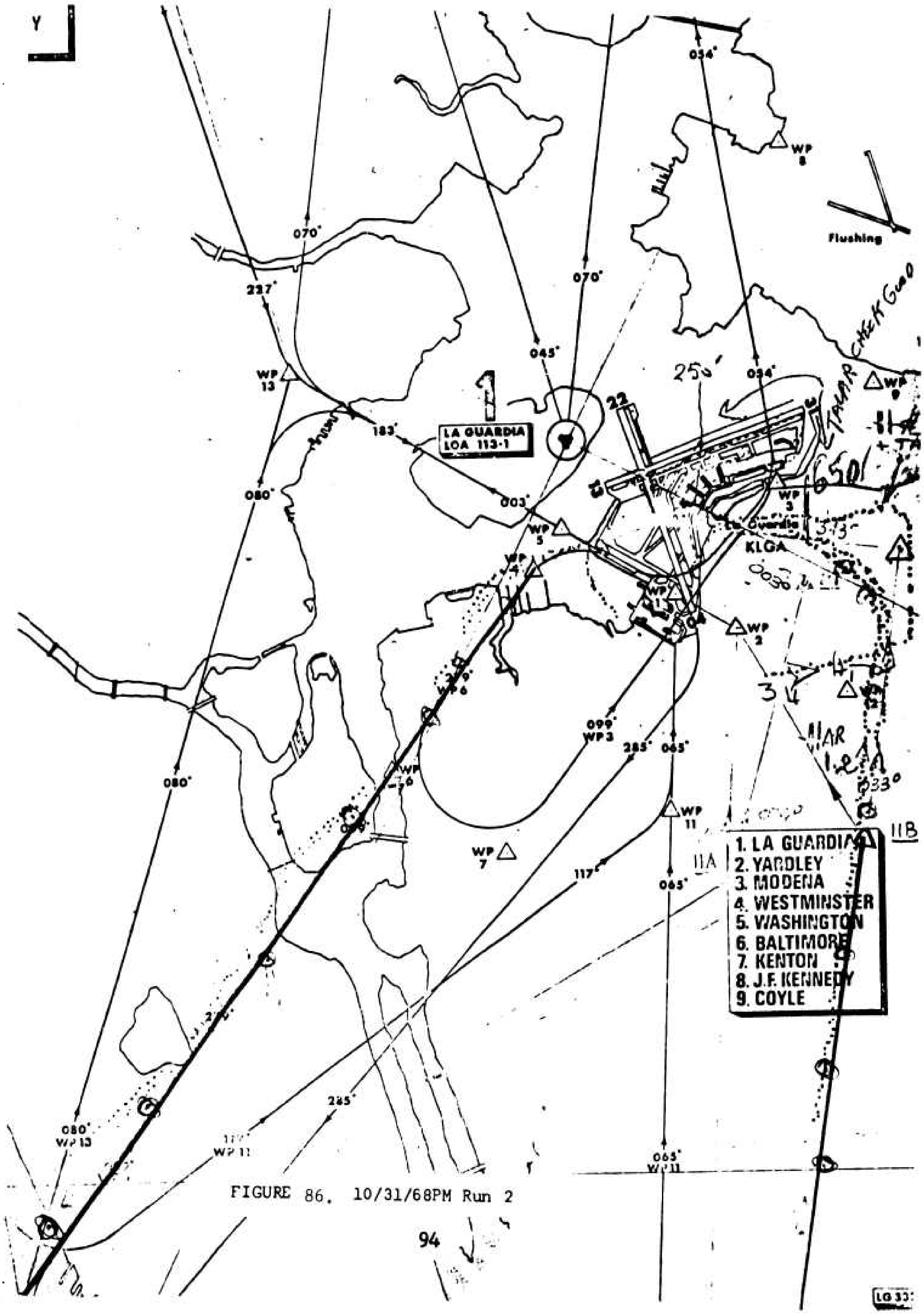


FIGURE 86. 10/31/68PM Run 2

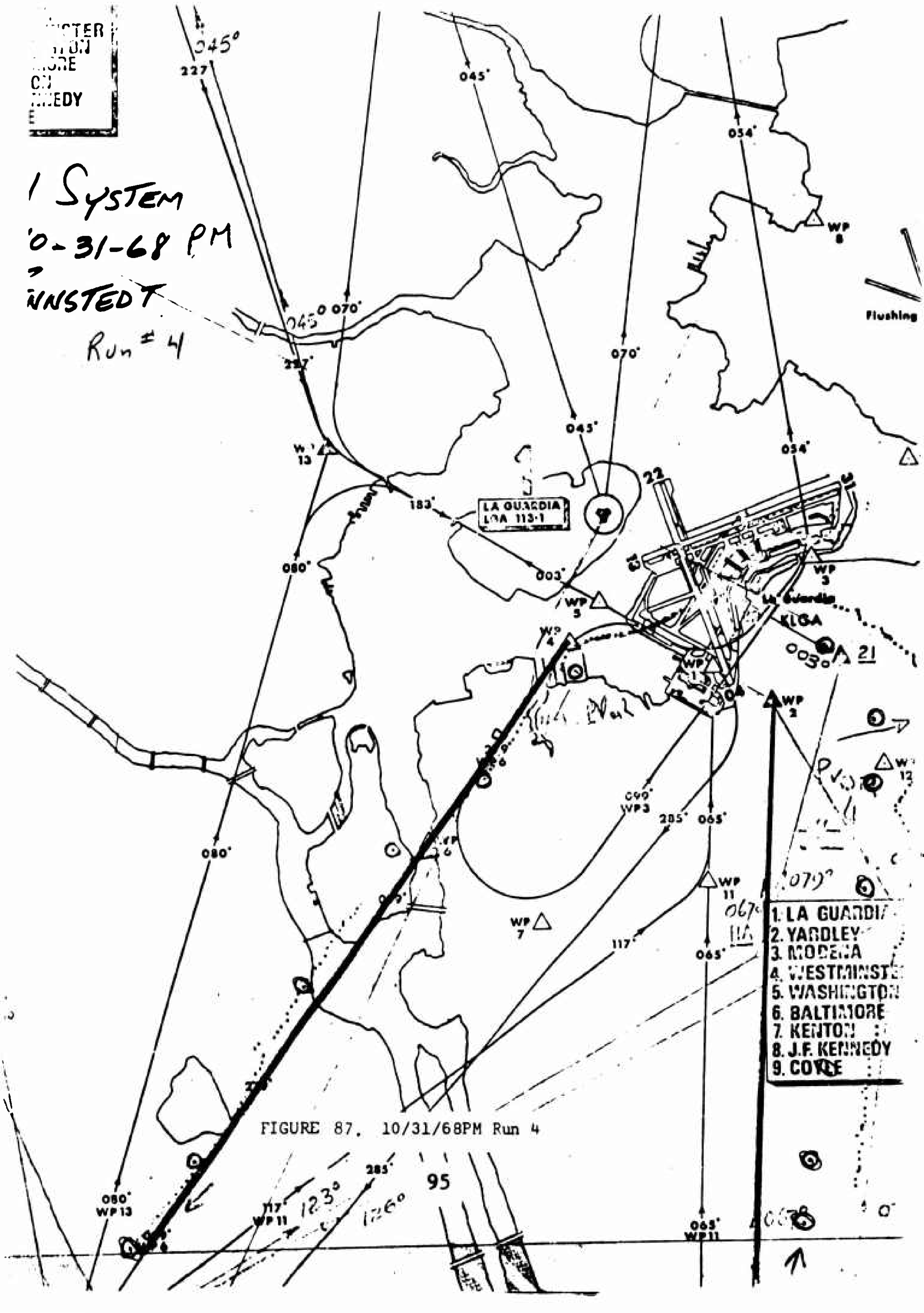


FIGURE 87. 10/31/68PM Run 4

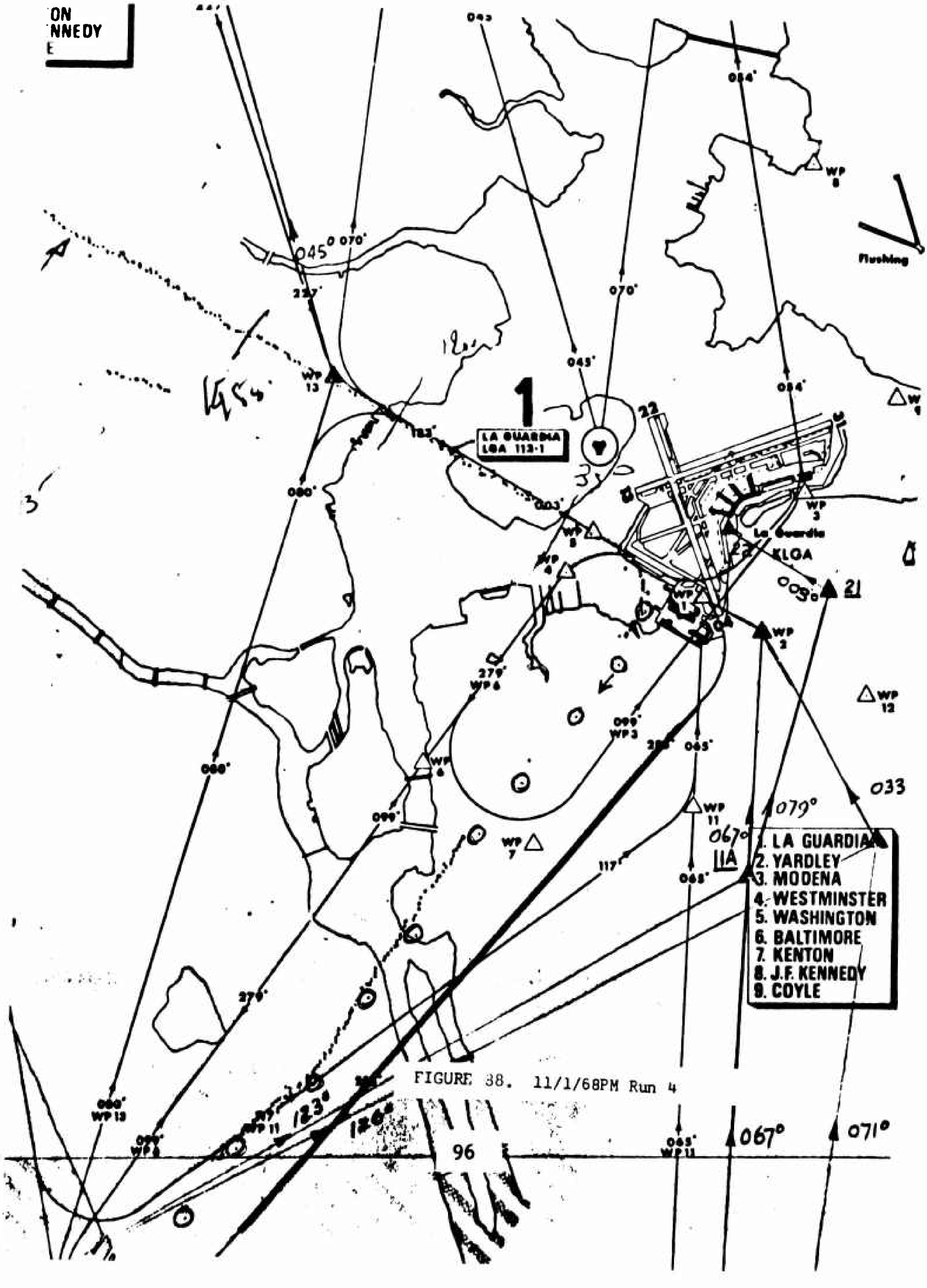


FIGURE 38. 11/1/68PM Run 4

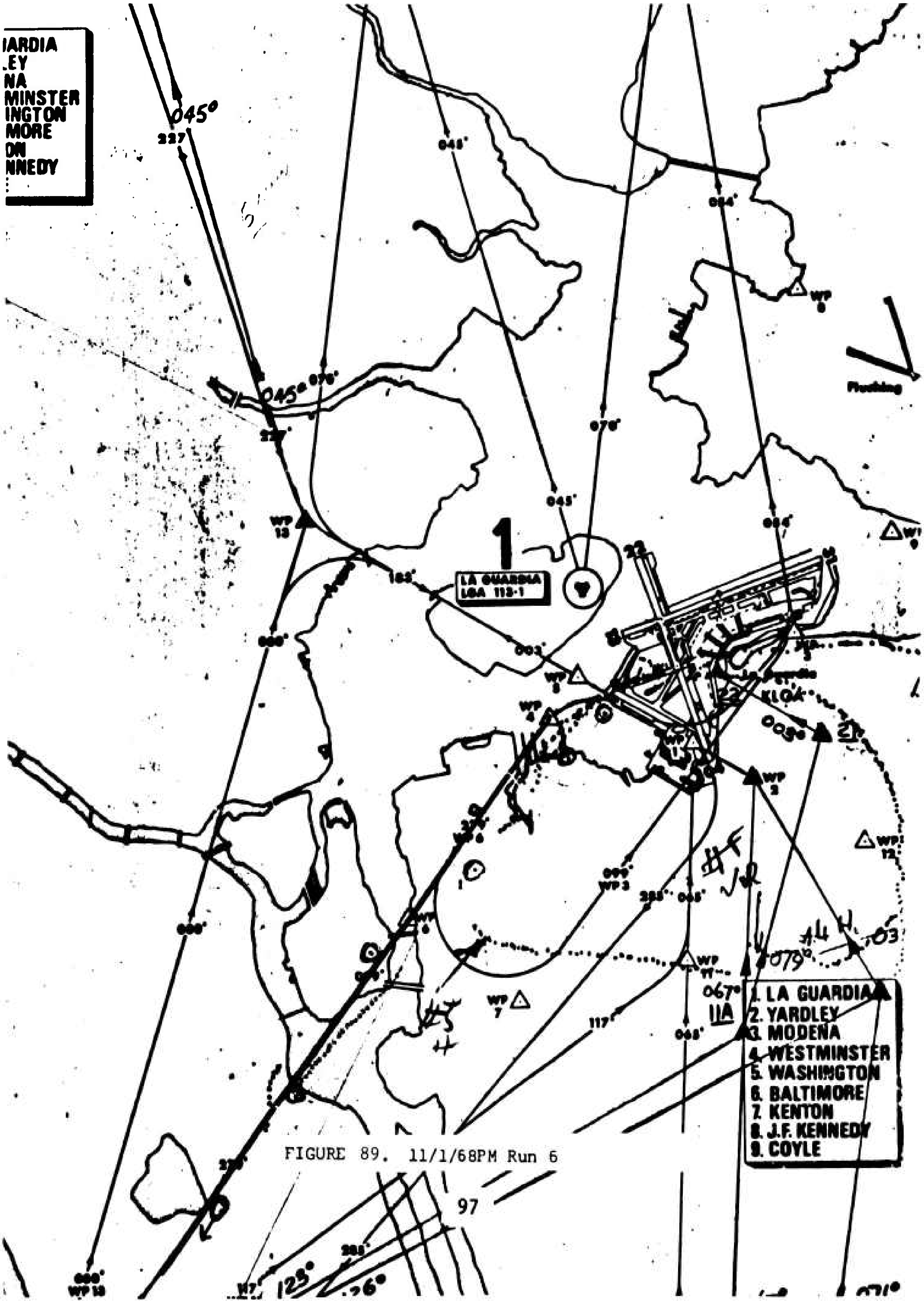


FIGURE 89. 11/1/68PM Run 6

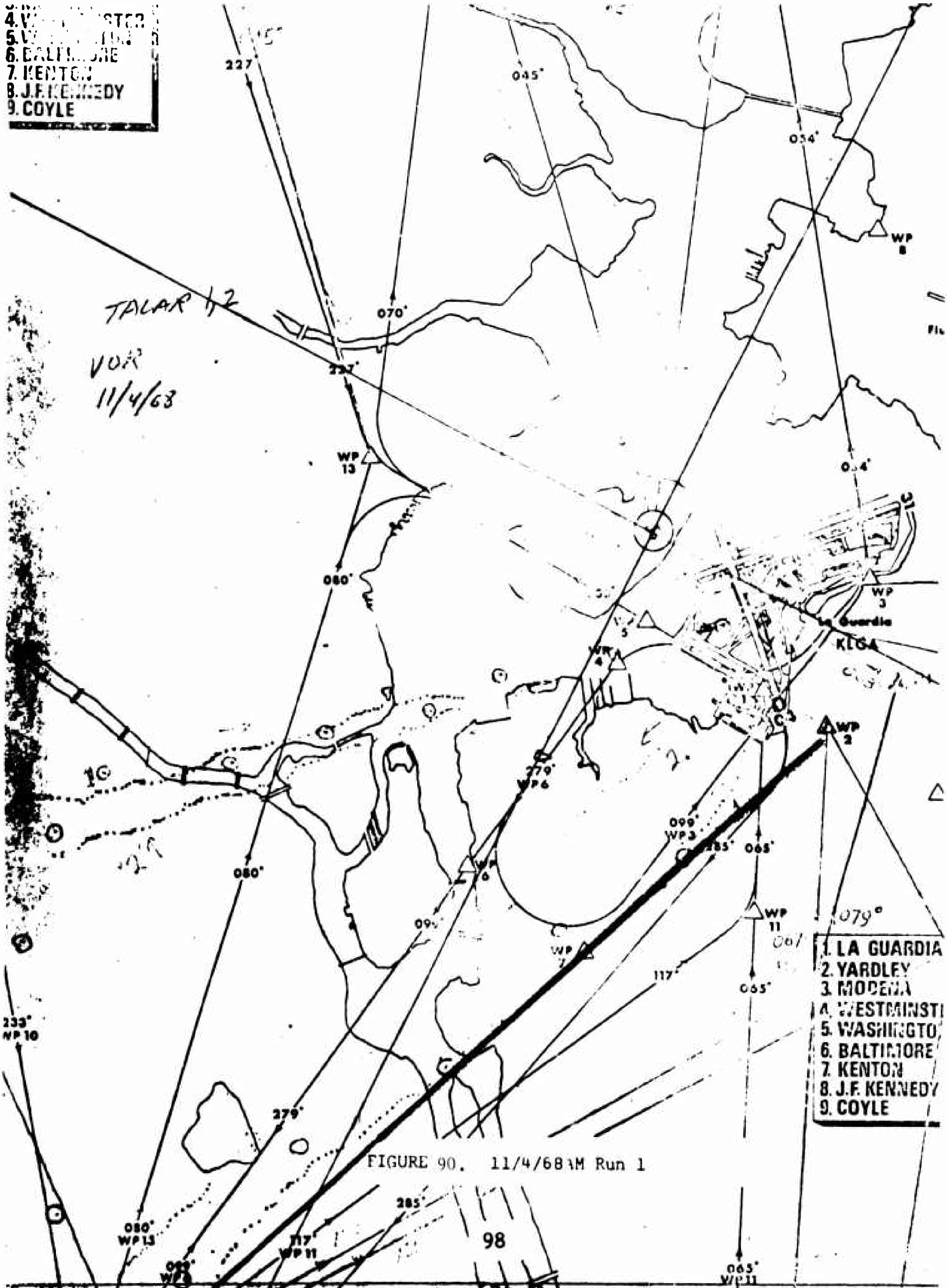


FIGURE 90. 11/4/68 AM Run 1

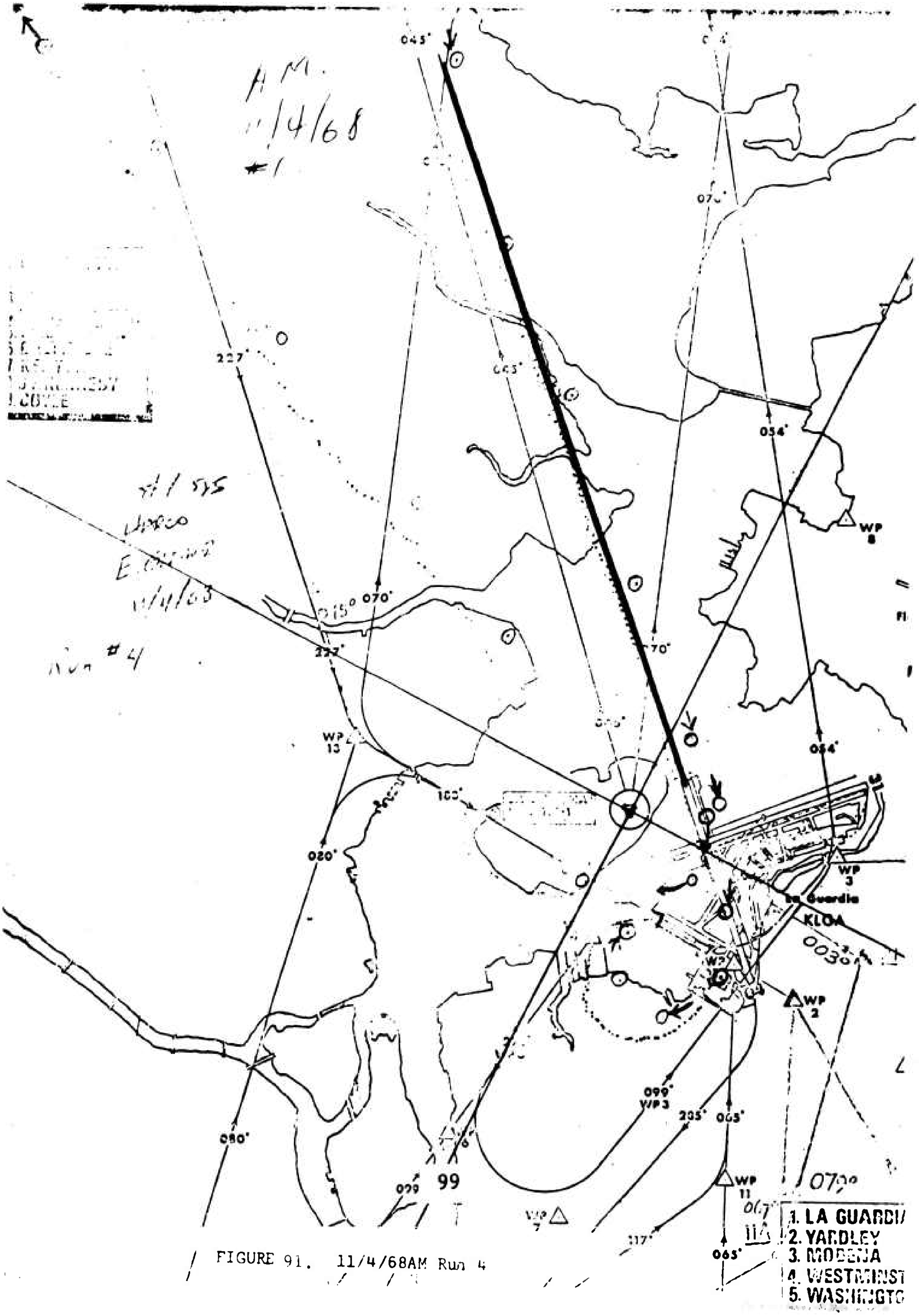


FIGURE 91. 11/4/68AM Run 4

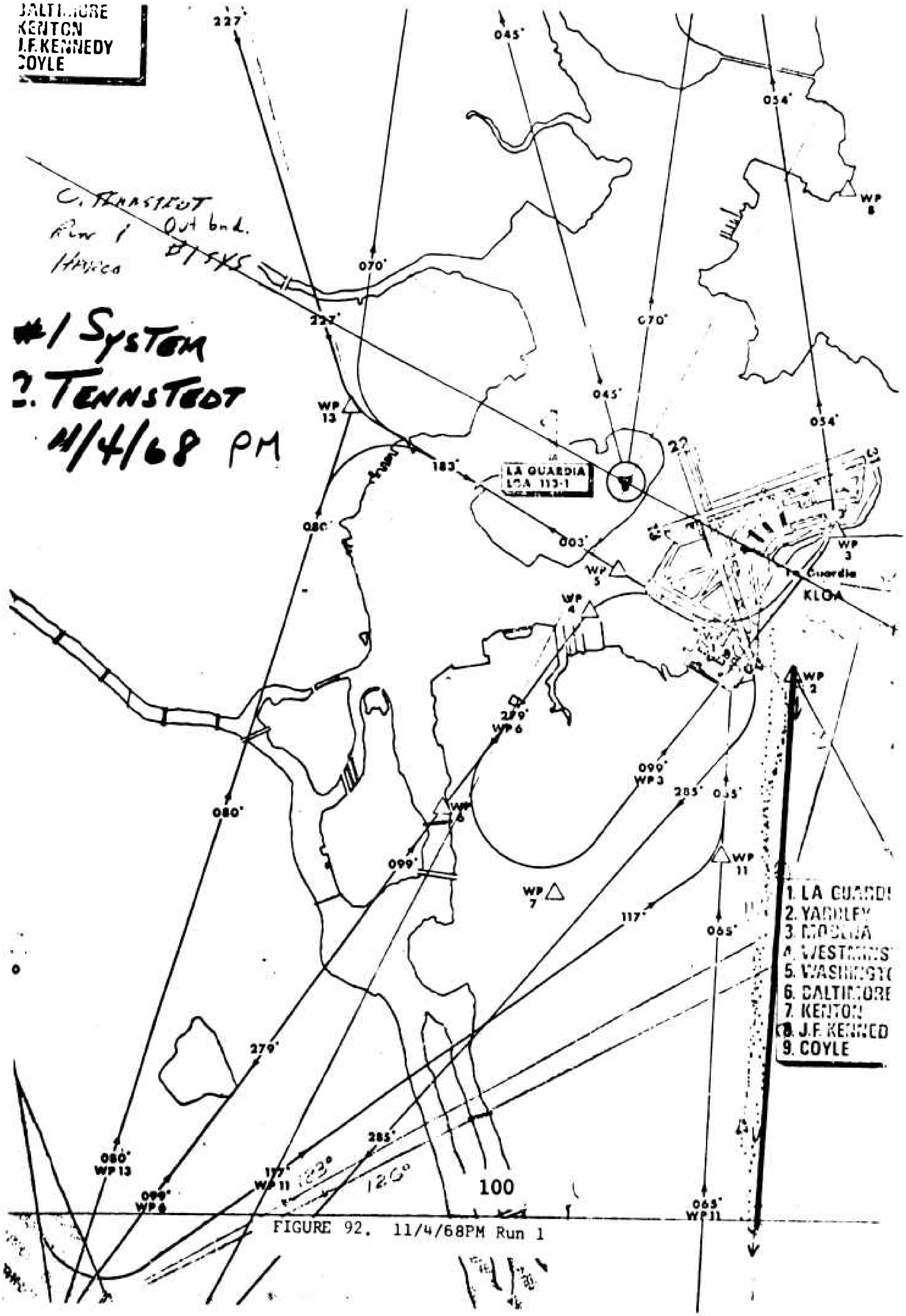


FIGURE 92. 11/4/68PM Run 1

Run #2 SYS 1
VOR DME
11/4/68 PM

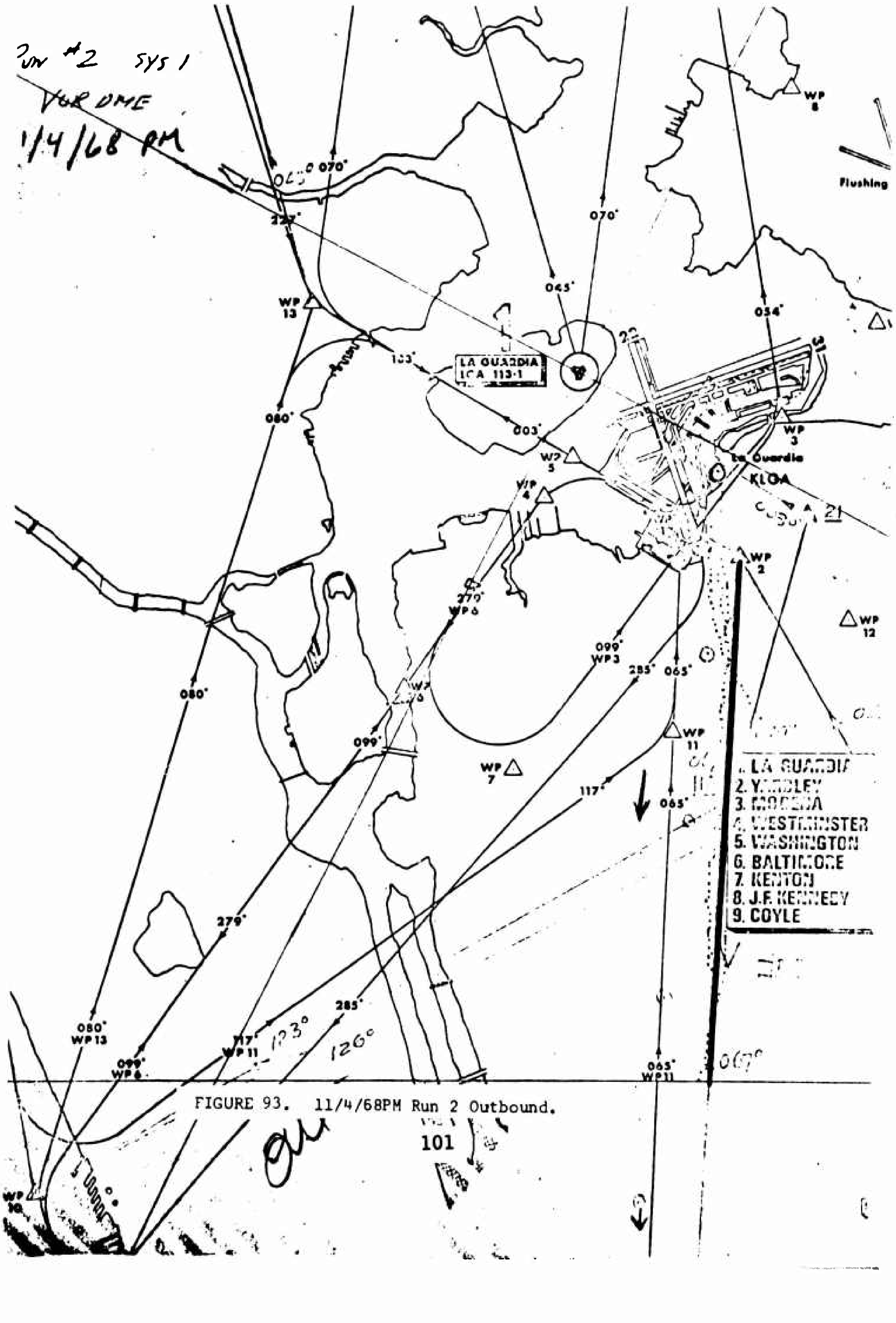


FIGURE 93. 11/4/68PM Run 2 Outbound.

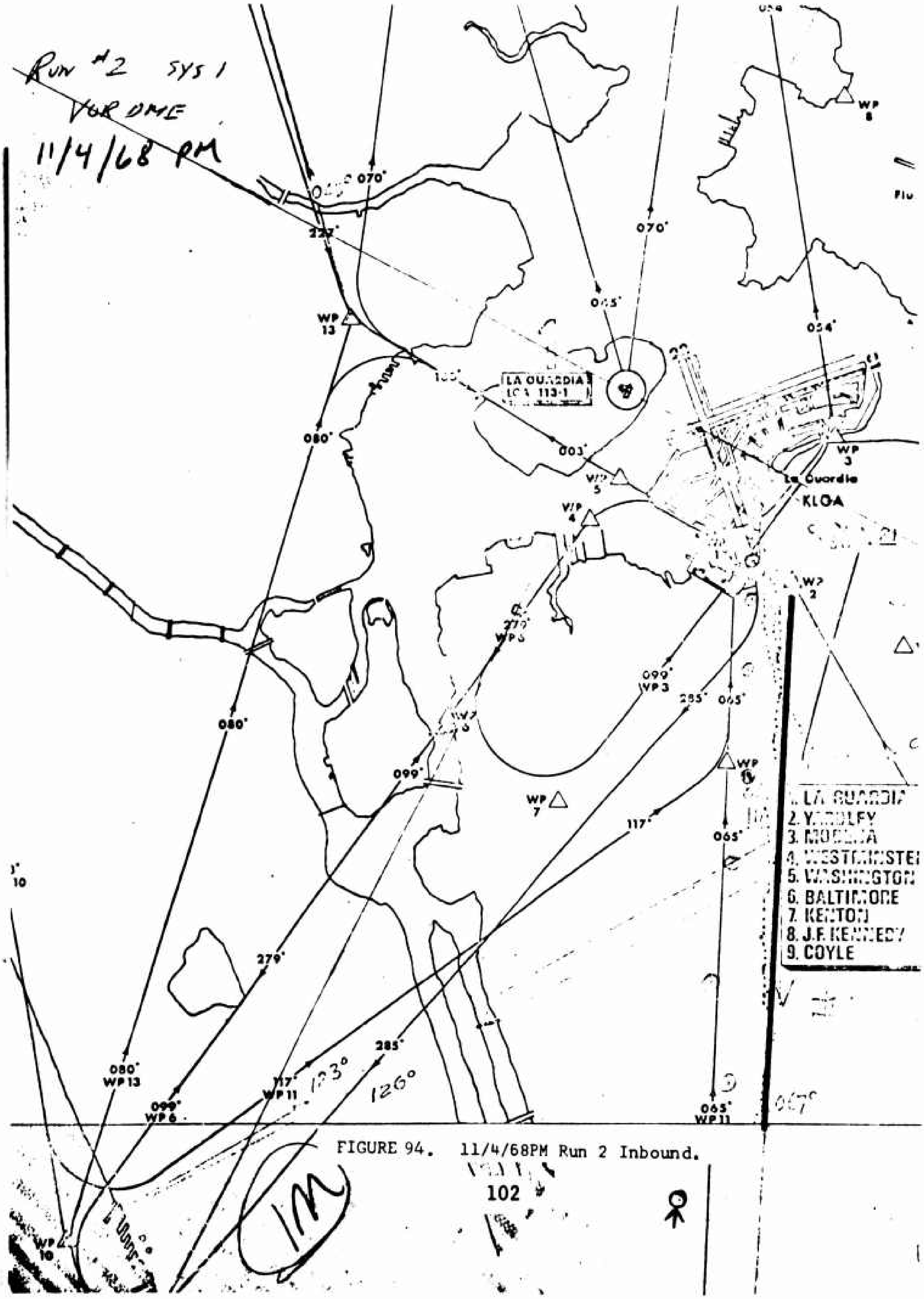


FIGURE 94. 11/4/68PM Run 2 Inbound.

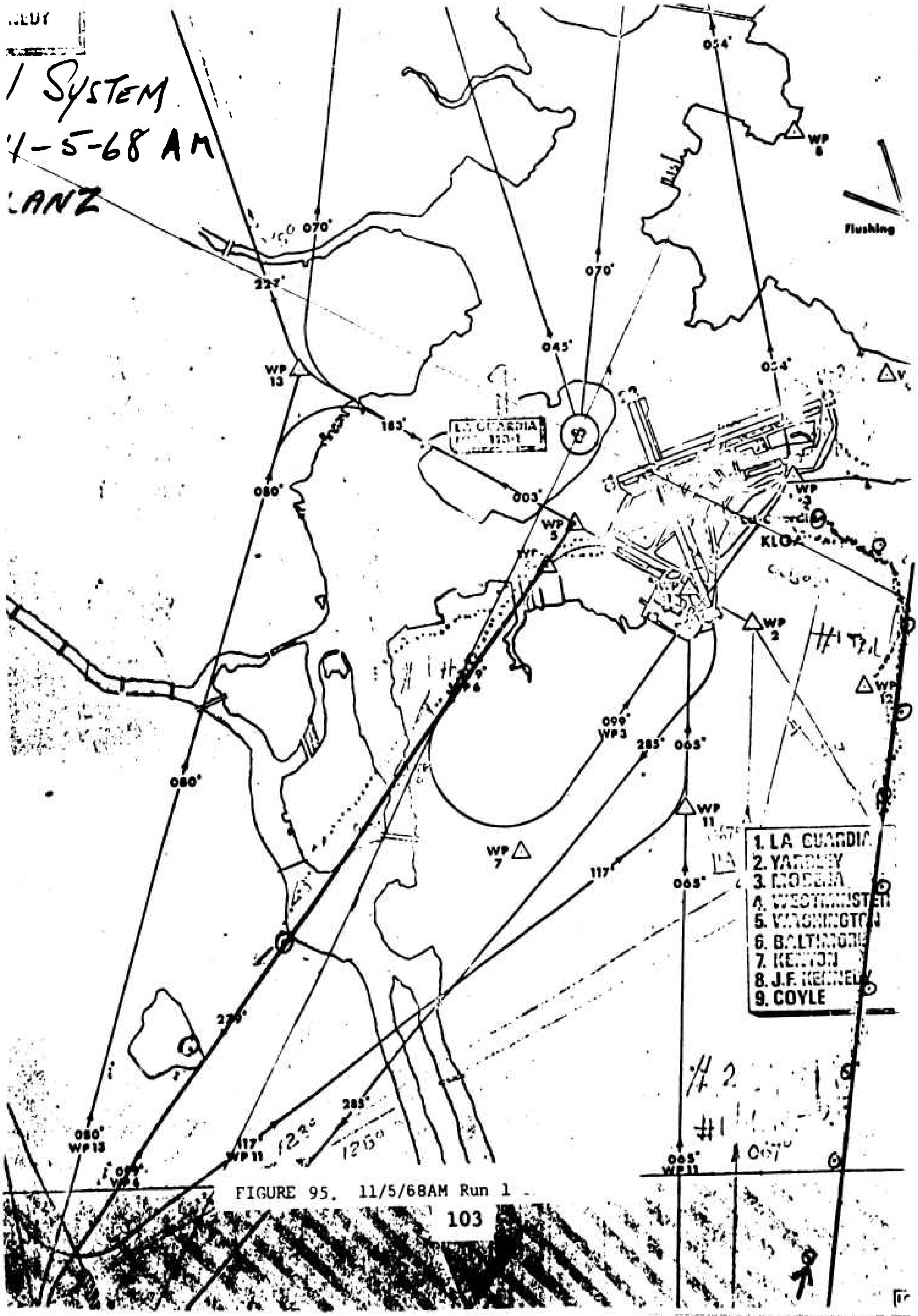


FIGURE 95. 11/5/68AM Run 1

1 SYSTEM
11-5-68 AM
LANZ

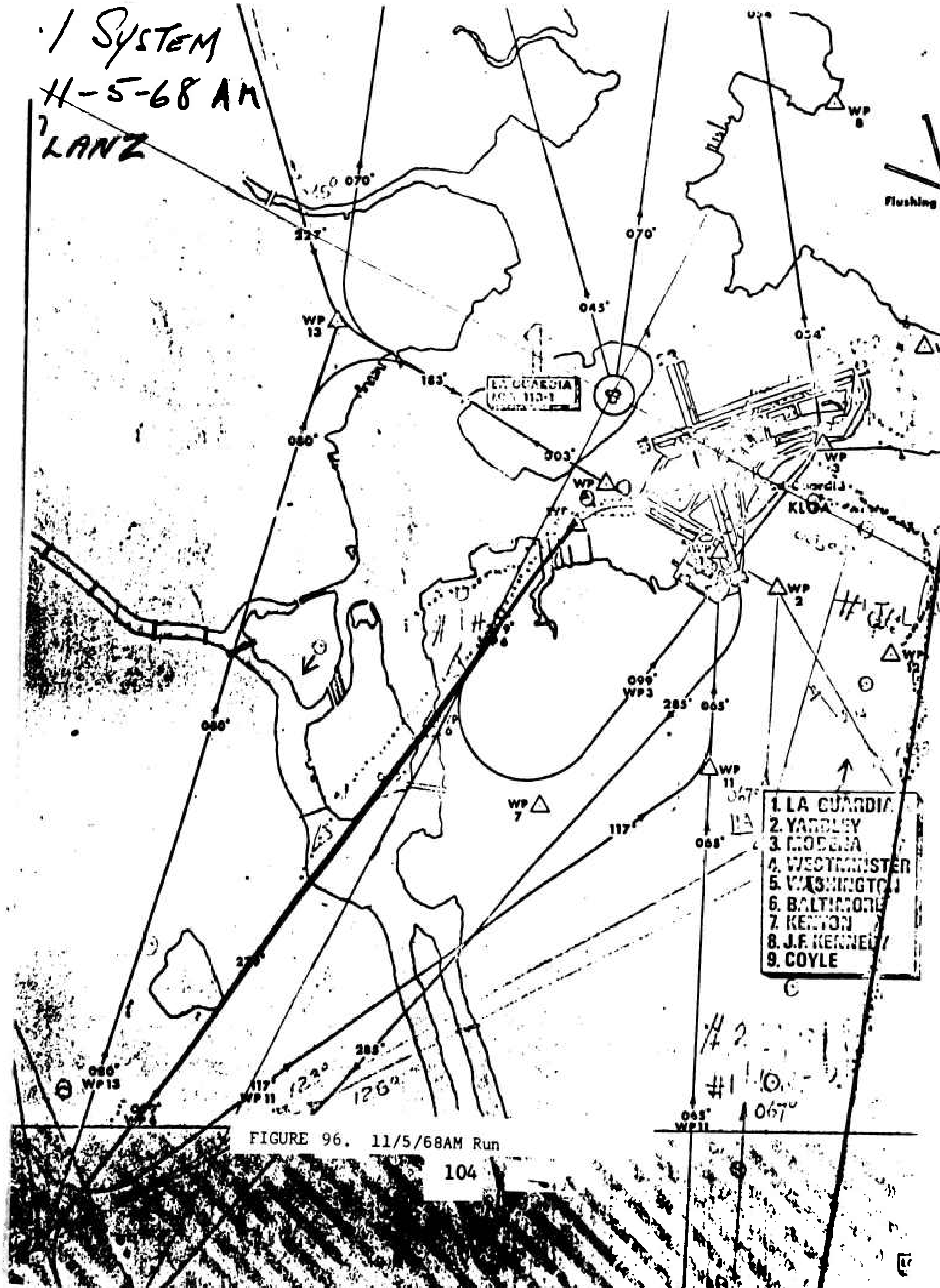


FIGURE 96. 11/5/68AM Run

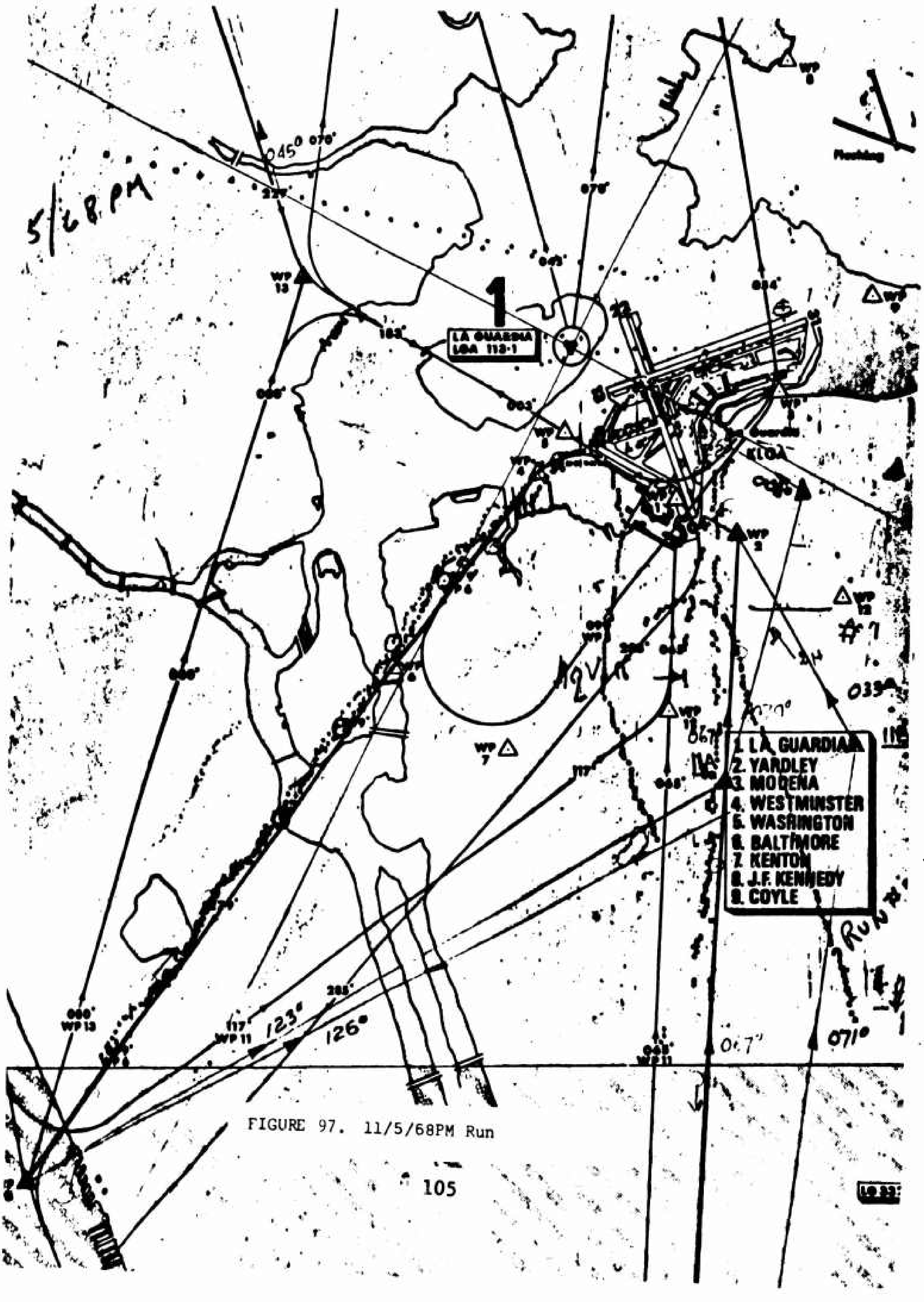


FIGURE 97. 11/5/68PM Run

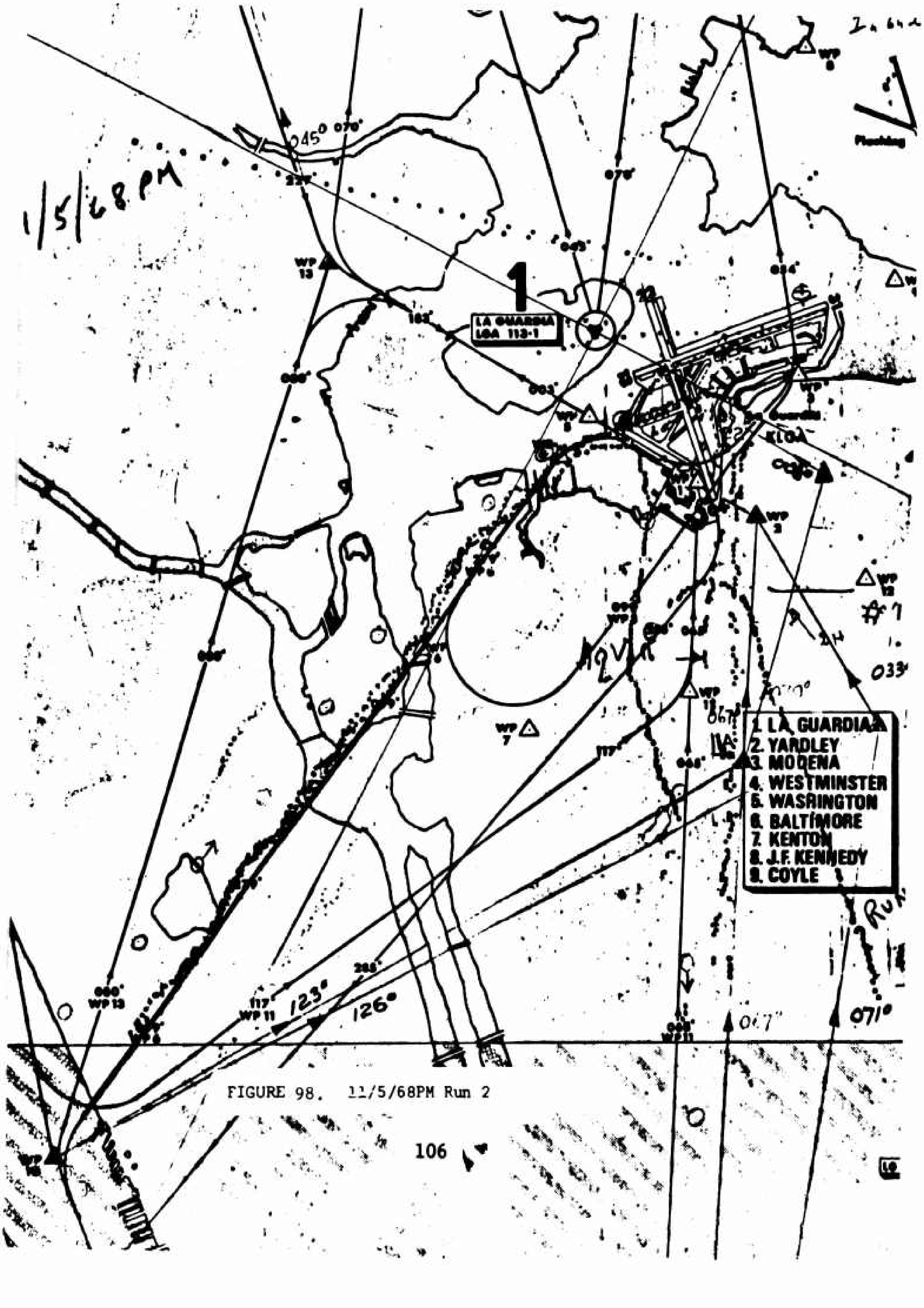


FIGURE 98. 11/5/68PM Run 2